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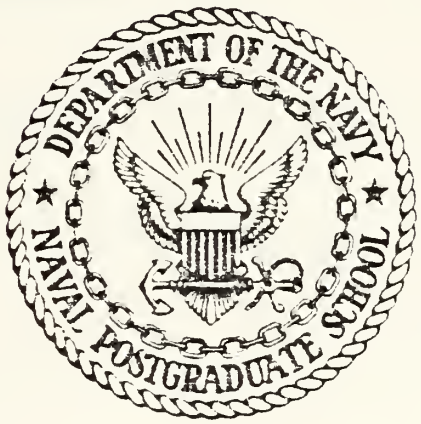


# THESIS

MANAGEMENT CONTROLS
IN
NAVY COMPUTING CENTERS

by

Dewey R. Collier
Thomas L. Hoffman

March 1984

Thesis Advisor: Carl R. Jones

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The rapid growth of information systems technology has created new challenges for the information/computer center management. Major investments in computer hardware and software and expansion of the data processing roles in many organizations has had profound effects on the management of those organizations. A management control system must be used to 1) provide communication between the user and the data processing activity to act in the best interests of the organization, 2) encourage effective and

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This thesis provides a managerial guide by which a computing facility manager can implement a management control system or evaluate an existing system.

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# Management Controls for Navy Computing Centers

by

Dewey R. Collier
Lieutenant Commander, United States Navy
B.S., Auburn University, 1971

and

Thomas L. Hoffman
Lieutenant Commander, United States Navy
B.S., U.S. Naval Academy, 1971

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requirements for the degree of

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NAVAL
MONTEREY, CALIFORNIA 93943

## ABSTRACT

The rapid growth of information systems technology has created new challenges for the information/computer center management. Major investments in computer hardware and software and expansion of the data processing roles in many organizations has had profound effects on the management of those organizations. A management control system must be used to 1) provide communication between the user and the data processing activity to act in the best interests of the organization, 2) encourage effective and efficient use of the information resource and 3) provide information relevent to future investment decisions. Each organization has specific organizational objectives that change over time and therefore requires a control system mechanism that must be sufficiently flexible to continue to meet those objectives.

This thesis provides a managerial guide by which a computing facility manager can implement a management control system or evaluate an existing system.

TABLE OF CONTENTS


I. INTRODUCTION . . . . . 8
A. ROLE OF MANAGEMENT CONTROL SYSTEMS . . . . . 8
B. CONTROL SYSTEM PROBLEMS FACING INFORMATION MANAGERS . . . . . 11
1. Information Explosion . . . . . 11
2. Software Development . . . . . 13
3. Costing . . . . . 15
4. Planning and Budgeting . . . . . 18
5. Auditing . . . . . 19

II. ORGANIZATIONAL OBJECTIVES AND THE CONTROL SYSTEM . . . . . 22
A. GOALS OF A CONTROL SYSTEM . . . . . 22
B. ORGANIZATIONAL VS. INFORMATION RESOURCE PLANNING . . . . . 25
1. Organizational Plans vs. Information Resource Plans . . . . . 26
2. User Involvement . . . . . 29
3. Economic Analysis . . . . . 34

III. ELEMENTS OF A CONTROL SYSTEM . . . . . 39
A. ORGANIZATIONAL STRUCTURE AND THE CONTROL SYSTEM . . . . . 40
B. COSTING SCHEMES . . . . . 41
C. DEVELOPMENT OF STANDARDS . . . . . 44
D. MEASURES OF PERFORMANCE . . . . . 45
E. COMPARISON OF PERFORMANCE TO STANDARDS . . . . 48
F. PRIORITIZATION OF JOBS . . . . . 49
G. MANAGEMENT REPORTS . . . . . 53

H. CORRECTIVE ACTION . . . . . 57

IV. STEPS IN DEVELOPING A CONTROL SYSTEM . . . . . 59

A. ESTABLISH GOALS AND OBJECTIVES . . . . . 59

B. SET POLICIES AND PROCEDURES . . . . . 61

C. ORGANIZATIONAL STRUCTURE AND THE CONTROL SYSTEM . . . . . 62

D. SET STANDARDS . . . . . 64

E. DETERMINE MEASURES OF PERFORMANCE . . . . . 67

F. COMPARISON OF PERFORMANCE TO STANDARDS . . . . 71

G. MANAGEMENT REPORTS . . . . . 72

H. CORRECTIVE ACTION . . . . . 82

V. EVALUATION GUIDE . . . . . 85

A. INTRODUCTION . . . . . 85

B. ORGANIZATION . . . . . 87

C. MISSION . . . . . 88

D. GOALS AND OBJECTIVES . . . . . 88

E. OPERATIONS . . . . . 88

F. PERFORMANCE MEASUREMENT . . . . . 91

G. STANDARDS . . . . . 93

H. PERFORMANCE EVALUATION . . . . . 93

I. PLANNING . . . . . 95

J. TRAINING . . . . . 96

K. PERSONNEL . . . . . 96

L. USER INTERFACE . . . . . 97

VI. CONCLUSIONS . . . . . 99

A. SUMMARY . . . . . 99

B. RECOMMENDATIONS . . . . . 100

LIST OF REFERENCES . . . . . 102

INITIAL DISTRIBUTION LIST . . . . . 110

## LIST OF FIGURES


1.1 Cost . . . . . 16

2.1 Possible Implications of Excess Dominance . . . 31

2.2 Project Cost Data Elements . . . . . 38

4.1 Use of Data by Management and Decentralized Units . . . . . 63

# I. INTRODUCTION

## A. ROLE OF MANAGEMENT CONTROL SYSTEMS

A management control system is a critical network which integrates the organization's operations [Ref. 1]. It focuses on guiding the organization on a year-to-year basis but does so in such a way as to be consistent with the long-range organizational strategy. A "management control system builds on the output of the planning process to develop a portfolio of projects, hardware/software enhancements and additions, facilities plans, and staffing levels for the year" [Ref. 2]. The management control system monitors the progress of these developments and alerts appropriate levels of the organization when performance deviates from the expected standards. Control systems for a Navy computing facility should be adapted to a very different software and operations technology in the 1980's than was present in the 1970's [Ref. 3]. The management control system must take into account the sophistication of the users, geographic dispersion of the organization, stability of management, the organization's structure, and the interdepartmental relationships [Ref. 4]. The significance of the computing facility in the overall organizational strategy is an important consideration in how tightly the management control system should be maintained.

Within the Navy, computer centers are operated as independent service organizations. They provide services to "client" organizations, as in the case of a Naval Automated Regional Data Center (NARDAC) supporting the inventory functions of a Naval Air Rework Facility (NARF) or as a data processing center within a Navy Supply Center organization

supporting the functions of other departments at that Supply Center. Traditional management control models have stressed the financial control architecture, the financial control process and the audit function. In an operational sense the non-financial management control system is just as important in the day-to-day management of the data processing center. The computer center manager must survey the user community to determine the adequacy of data processing support being provided, the status of user service agreements, and forecasts of user requirements for long-range system acquisition and utilization planning.

The control system provides data on the status of the organization's operations. It is a means, not an end in itself. The control system "helps the organization meet its objectives, not find wrongdoers" [Ref. 5]. Additionally, the computer center manager must be concerned not only with "controlling data center activities so that performance standards are met, but also how procedures and technology can be modified to permit the setting of higher performance standards" [Ref. 6]. According to Schaeffer, computer center managers have three tools that have proved successful in controlling data center activities: " the receipt of management reports, the existence of an active data center steering committee, and availability of a user/data center handbook" [Ref. 7]. These three tools can be used to provide managers with critical information on which to base reasonable decisions, provide a channel of communication between the data center and user representatives and provide explicit documentation on the functional organization and operating procedures of the data center [Ref. 8].

Organizations differ in their abilities to measure either output or behavior which is relevent to a desired perfomance. Ouchi [Ref. 9] describes three fundamentally different mechanisms through which organizations manage this

problem of evaluation and control. The three frameworks fit well into the schemes for control systems that must be developed for computer facilities. The three frameworks Ouchi describes are called markets, bureaucracies, and clans. "The problem of organization is the problem of obtaining cooperation among a collection of individuals or units who share only partially congruent objectives" [Ref. 10]. The frameworks determine the type of control process which effectively eliminates the goal incongruence and is defined by the different characteristics of behavior, output or process measurement within each framework. Fundamentally, in a market the control problem is managed by its ability to precisely measure outputs; bureaucracies rely upon the measurement of the process; and clans use a socialization process which uses cultural influences to guide behavior towards congruent goals because of an inability to obtain quantifiable measurements. Of course, in reality a pure market, bureaucracy or clan would not exist. "Real organizations will each contain some features of each of the modes of control" [Ref. 11]. The design problem thus becomes one of assessing the characteristics of measurement and determining the proper form of control [Ref. 12].

Indeed, the ability to measure either output or process which is relevent to the desired performance is a key issue in determining the proper form of control. The basic and fundamental assumption underlying any bureaucratic or market form of control is the assumption that it is, in fact, feasible to measure with reasonable accuracy the performance which is desired [Ref. 13]. A control system based on ambiguous and inappropriate measurements is likely to be ineffective and under such conditions, the clan form of control, which stresses values, educational background, and behavior may well be preferable.

Two key issues, therefore, in design of a management control system for a computer facility are the clarity with which performance can be assessed and the degree of goal congruence. These two dimensions are stated by Ouchi to be "intimately related in determining forms of control." The problem for the manager when designing a control system is to discover the balance of socialization and measurement which most effectively promotes goal congruency.

Summarizing, the role of management control in an organization is to assist management in the planning, coordination and control of the organization's responsibility centers where " a responsibility center is a group of people headed by a manager who is responsible for what it is doing" [Ref. 14].

## B. CONTROL SYSTEM PROBLEMS FACING INFORMATION MANAGERS

### 1. Information Explosion

A major stimulant to information system growth is the emergence of groups of experienced computer systems users. As the users become familiar with the capabilities of information and data processing centers, they generate additional data processing requirements. If an effective control system is not in place to appraise the potential costs and benefits of new requirements the organization may experience " explosive growth...with new capacity required every one or two years" [Ref. 15]. There must be a balance between innovation and control. The management of the data processing center and the user management must clearly understand and agree to the policies of control.

The control system must deal with capacity expansion in a manner that is consistent with both data center and user management objectives. Complex trade-offs exist in the areas of capacity utilization emerging from the Nolan phases

of "initiation, contagion, control and integration" and user innovation. In a situation where congruent management goals encourage user exposure and interest in new adaptations and applications, the control system significantly differs from the situation where user applications are nearing the capacity saturation point and the management goal is controlling a scarce resource. The trade-offs made in innovation, with its accompanying risks and payoff opportunities, versus conservatism and the inherent reliability, must be reflected in the type of management objectives involved and the emergent control system [Ref. 16]. Organizations which stand to benefit either from significant cost reductions or process efficiencies or competitive technological advantages should adopt control systems that allow and encourage more innovation than one that has a great deal of dependence on a smooth, reliable operation.

The control system must be responsive to the user's short-term requirements but not at the expense of the data processing center's orderly development and execution of the long-range planning inherent in the computer resource life-cycle. The management control system should be a tool to set an equilibrium between the user requirements and data processing center's plans and, at the same time, ensure that the operations support the overall organizational objectives. The control system must also not be overly cumbersome or restrictive or users will be encouraged to seek alternative or multiple sources of computer services.

According to Schaeffer [Ref. 17] an excellent channel for bringing together data center and user department representives is the data center steering committee. This can be a mechanism for fostering rapport and mutual assistance between the users and data processing organizations. The activities of the committee should include: "coordination of data center and user activities, resolution

of scheduling difficulties, data center management's awareness of upcoming resource demands, user awareness of application processing problems and inefficiencies, and review of alternative processing approaches" [Ref. 18]. Additional issues to be addressed are: status of user service agreements, user service profile trends, and user involvement in application program development. The user functional domain and the data processing center's functional domain must be clearly set and agreed upon so control systems can be specifically designed and modified to support the long-term organizational strategies and near-term emergent requirements. Control of new requirements and new technology must be a major facet of a management control system. The management control system must balance innovation and control of the computer resources in a way that is sensitive to changing demands of the users and provide a framework for efficient and effective resource utilization.

2. Software Development

The recent shift in the corporate world to purchased software instead of in-house construction is a primary concern for the data processing center. The proliferation of user microcomputers or minicomputers poses some real problems for the data processing manager in terms of construction of new software, integration of in-house software with standard user-oriented, purchased software and maintenance of both existing and newly purchased software. The supply of cheap commercial software is growing dramatically and many vendors offer various standard software packages, such as payroll and accounting, as well as report generators and procedural languages. The problem is particularly critical when the user has authority to buy and operate commercially available software while the data processing center still has responsibility for maintenance

of other services and ensuring compatibility of the commercial software with existing software. The data processing manager must deal with problems of span of control, centralization versus decentralization of the computing resource, effective resource utilization in terms of mainframe utilization and duplication of applications, and costs associated with loss of economies of scale in processing and storage. Cash [Ref. 19] identifies the following key issues for the data processing manager in loss of "operations monopoly control":

a) " How to maintain existing services while building appropriate and necessary data bridges to the new ones."

b) " How to evolve the IS operations organization from a primary integrated system of data processing to a series of services which are better focused on the specific needs of different users."

c) " How to develop user understanding of both their real operational responsibility over the systems under their control and how to interface effectively with the (data processing center)."

With these control issues in mind, the data center manager may want to consider a requirement that certain life-cycle management techniques, such as including software maintenance costs, be used when the user will be acquiring hardware or software for which the data center will continue to have maintenance responsibility. A benefit of the life-cycle management approach is that it will recommend a cost-benefit analysis for acquisition of new hardware and software that can be compared to the cost of the application run by the data processing center's mainframe. This life-cycle approach will help managers decide whether to implement a near-term fix by buying new software or hardware or take a longer-range, broader scope solution where the new

application can be integrated into the present data processing system.

Another management consideration that must be addressed if the users do acquire other computing services or software is that all computers and " office-of-the-future" products are candidates for interconnection to a variety of other machines [Ref. 20]. The movement toward networks and distributed data systems will require that the user's hardware and software be compatible with a data-base management system needed to operate with distributed data bases. The long-range planning involved for software development is therefore not a trivial matter. Software development decisions must be an integral part of the data processing management strategy. The decision to buy off-the-shelf software for a user function may seem a relatively small decision to make now, but it can have a significant impact on the user and data processing center's interface and management relationship in the future. The management control system must therefore address controls on the development or purchase of new software.

The management control system must also monitor the extent of software maintenance as well as the resources used and costs associated with the maintenance. Theoretically, the maintenance costs could exceed the cost of a new software system but the data processing manager would not know this unless he had some measure of performance of the existing software system. Some measures that can be used are the direct labor costs (programming), down-time associated with software maintenance, and computing capacity utilized for implementation of the new or modified software.

### 3. Costing

The costs associated with operating a data processing center include much more than the costs attrib-

uted to the computer hardware. "Today, it is not uncommon for the hardware costs to account for less than 20 percent of the total data processing costs" [Ref. 21]. Some of the categories of costs illustrated in figure 1.1 are suggested

| COST | EXPLANATION | EXAMPLES |
|---|---|---|
| Hardware | Physical equipment supplied by vendor | - Computer memory<br>- CPU<br>- Printer<br>- Disk Drive |
| Vendor Software | Vendor-supplied programs which facilitate the operation of the computer | - Operating Systems<br>- Compilers<br>- Generalized Applications |
| Specialized Application Systems | Programs especially developed for the organization utilizing them | - Payroll<br>- Accounts Receivable<br>- Accounts Payable |
| Space | Facilities needed to house the computer and the people needed to support it | - All or parts of buildings<br>- Heat, lights, etc.<br>- Maintenance |
| Support-Vendor | Service and help supplied by the vendor | - Training<br>- Equipment Maintenance |
| Support-In-House | Service and help supplied by the organization | - Computer Operators<br>- Programmers |
| Supplies | Computer media and supplies needed to operate the computer facility | - Disk packs<br>- Printer paper<br>- Punch cards |
| Other | Items not included in the above considerations | - Value of money<br>- Startup costs<br>- Insurance |

**Figure 1.1 Cost.**

by Perry [Ref. 22].

A key issue facing the data processing center manager is how to measure and allocate costs in such a way as to encourage effective use of the computer center resources. Cost behavior has been greatly influenced by emerging computer technologies, shortage of trained computer specialists [Ref. 23] and the aforementioned "information explosion". For example, technical advancements have generated replacement hardware with 4 to 10 times [Ref. 24] more capacity than existing ones with costs less than the original equipment's purchase price. In a chargeback environment the data center manager must decide whether to spread all of the present costs on to their current users or forecast future costs and set a multi-year average which would recover costs at the end of the period. If the manager chooses to cover expenses from the start, higher prices (per unit of information) may inhibit user innovation and application experimentation. On the other hand, a multi-year average cost decision could encourage (by lower prices) more capacity useage and spark new application development.

The effect of cost allocation is not a trivial matter in a chargeback enviroment. Where users are charged for computer services, either by chargeback or reimburseables, costs allocation has a significant impact on the type and quantity of services requested and future application development requests. Users are motivated "to be concerned about the value of services they receive and managers are motivated to be concerned about the costs and quantity of services they provide" [Ref. 25].

In a "service center" situation, costs are normally accumulated in the data processing center budget and the costs are allocated indirectly, not on the basis of service to the users. When the data processing is offered to users basically " free of charge" the manager must deal with uncontrolled growth of new applications, system saturation,

inefficient programs, poor or non-existent job prioritization and little or no controls for efficient and effective resource utilization. The advantages of this costing scheme is simplicity, lower accounting costs, and increased user experimentation [Ref. 26].

4. Planning and Budgeting

The computer center manager has a complex problem in planning and budgeting. As will be discussed later the data center manager must reconcile the plans, formulate and execute the budget and develop audit techniques to support the organizational goals. In a chargeback accounting scheme, the budget must identify those items that will be "mission budgeted" as overhead and those costs that will be charged-back to the users. " A budget is a quantitative expression of a plan " states Leonard I. Krauss [Ref. 27]. It is an opportunity to emphasize effectiveness in terms of production and costs and an opportunity to implement new ideas created by a long-range plan. A budget mandates that management think ahead and plan responsibibly. The translation of the plans into a budget provide a suitable framework for developing management controls and evaluating financial performance. The manager must translate the plans into terms that correspond to the centers of responsibility that are charged with executing that portion of the plan. This translation is a statement of the outputs expected during the budget year and the resources to be used in achieving these outputs. The melding of organizational plans into the budget also provides a mechanism for coordination of effort and resources and consolidation of resource requirements to be more effective in resource assignment.

The data processing manager has to consider the following things in preparing a budget:

a) User demand and resource supply for computer services,

b) The effect on "sales" of service pricing, quality and responsiveness,

c) The effect of commercial competition,

d) How to generate new users.

Because accurate and reliable cost estimates are needed for an effective budget, the data center manager must receive inputs from the users on the volume, type, quantity, etc. of services that will be requested of the computer center. These inputs must be incorporated in a functional categorization of the data processing budget. The data processing manager must forecast the user's demand based on variable prices and develop budgetary controls to monitor the conformance to the financial constraints.

5. Auditing

There is a significant relationship between the data processing department and the audit process. This relationship affects the data processing "stability, effectiveness, and even its survival" [Ref. 28]. Audits can come in two forms: (1) external or (2) internal and with two points of view: (1) financial or (2) data processing management and operational functions.

The external audit is normally done by personnel outside the organization hired as an objective source to comment and verify the organization's financial posture. Although not always trained or experienced in data processing, external auditors will be interested in the following areas: [Ref. 29]

a) The authenticity of computer-generated financial data.

b) The control and security of data.

c) The physical security of the data center.

d) The documentation of standards and procedures.

An internal audit of data processing center will normally be conducted by the organization's own staff. Areas of primary concern will generally include:

a) The adherence to organization's policies, rules and regulations.
b) The efficient use of resources.
c) The physical security of the data and data center.
d) The documentation of standards and procedures.
e) The long-range resource (facilities, equipment, etc.) planning.
f) The audit staff involvement in system design.

While the data processing manager does not have the option to decline an audit, it is in the best interest of the data processing center to view the audit with a positive attitude for the following reasons: [Ref. 30]

a) An audit cannot be avoided.
b) An audit is an excellent, objective source of operational improvement suggestions.
c) An audit is an objective benchmark of what kind of job the facility is doing.

From a Navy-wide standpoint, the ideal situation would be to audit all data centers. This, however, may not be possible because of the number and geographic dispersion of the data centers. In deciding which data centers to audit or , for an internal audit, whether to do an audit, the following criteria may be used:

a) The center has been audited before and did not do very well.
b) The data center provides services for other activities.
c) The data center has large applications to manage or controls large assets.
d) The data center is a large installation in terms of hardware or personnel and represents a large investment in dollars or manpower.
e) Significant changes in equipment, mission or personnel have occurred since the last audit.

f) The operation exposes data processing personnel to potential for fraud or loss of control such as check writing, payroll, or on-line operations.

g) A critical computer-controlled application is involved such as a security system, computer-monitored or computer-controlled machinery.

The data center manager's problem is ensuring that enough controls are in place to not only ensure that the data center's operations run smoothly but also that the organization's activities are auditable. The development of the management control system must include methods to not only provide for effective and efficient resource utilization, but also include a structure that provides information for the inevitable audits.

## II. ORGANIZATIONAL OBJECTIVES AND THE CONTROL SYSTEM

### A. GOALS OF A CONTROL SYSTEM

The primary goal of a data center in its most general form is to " attain user and data center objectives through management control within an effectivlely structured organization" [Ref. 31]. The management control system is a set of processes through which organizations ensure that actual activities conform to planned activities [Ref. 32]. The control system must be a dynamic entity capable of responding and in fact stimulating response from the organizational constituents to the changing goals and objectives of the organization. It must be sensitive to the changing demands of the organization's clients and provide a framework for efficient and effective resource utilization in a climate of future planning and current organizational performance monitoring. Ultimately, a management control system answers the question "How are we doing?" in a manner that encompasses the organization's financial standing, output or production performance, status of current projects and progress toward the long-range organizational strategy.

Management has the responsibility to "define the general nature of the organization and its relation to the world" [Ref. 33]. The direction the organization will take and the results the organization wishes to achieve are communicated by management in the form of objectives. Time limits and specific performance measurements are assigned to these objectives. "The objectives should be measurable, attainable, comprehensive, and relevant to the data center's needs" [Ref. 34]. "An objective that is not measurable is frequently not an objective but a statement of function or

responsibility" [Ref. 35]. To avoid an atmosphere of frustration, resentment and job dissatisfaction among data center personnel, the objectives must also be attainable. "The statement of objectives is a key element in a management control system because an organization's effectiveness can be measured only if actual outputs are related to the objectives" [Ref. 36].

Schaeffer [Ref. 37] suggests that the objectives for a data center can be categorized as "user-oriented objectives and data center objectives. User-oriented objectives are timely processing and quality of the output." These two characteristic are not mutually exclusive and in most cases there is a trade-off not only in the user-oriented requirements of timeliness and quality but also data center objectives of cost and efficiency. Again, the user-data center communication becomes a paramount consideration in negotiating the standards of performance required to produce a quality service in a timely fashion to the user within the efficiency and cost constraints of the data center resources. Quality of output is a difficult standard to specify and can often only be stated in terms of what job or service is to be provided and what actions or precautions can be taken to ensure that the output is what is desired by the user. Such precautions include assurance of "backup for protection of critical files, appropriate response to program messages, verification of control totals" [Ref. 38], and proper processing and distribution of output.

Four critical data-center-oriented objectives are [Ref. 39]

1. Efficiency. "Doing things right", concerned with the cost of resources used in the applications [Ref. 40]. Getting the greatest amount of productivity from available resources with cost justification for obtaining the improved efficiency.

2. Security. Provide, within financial limits, the protection of equipment, systems, data and the personnel and premises.
3. Cost. "To (reduce) processing costs by documenting the causes for the data center's costs...".
4. Morale. "To (improve) personnel morale by stressing and stimulating participation, initiative, and personal improvement. Data center performance is affected by the competency and industry of its personnel. Both management and staff benefit from management's concern for personnel morale."

While Schaeffer's list of objectives addresses some critical issues, additional important objectives that are applicable to a data center are as follows:

1. Service. Timely and appropriate quality response to customers.
2. Innovation. Development and delivery of new products and services.
3. Planning. Improvement of short and long-range planning and decision-making.
4. Effectiveness. "Doing the right things", the right choice of applications for computer resources. [Ref. 41].
5. Control. Controlling performance so that standards are met.

To meet these data center objectives, Cash [Ref. 42] suggests some broad objectives that a management control system must meet:

1. "Facilitate appropriate communication between the user and deliverer of information systems (IS) services and provide motivational incentives for them to work together on a day-to-day, month-to-month basis. The management control system must encourage all users and IS to act in the best interests of the

organization as a whole. It must motivate users to use IS resources appropriately and help them balance investments in this area against those in other areas."

2. "Encourage utilization of the IS department's resources, and ensure that users are educated on the potential of existing and evolving technology. In doing so, it must guide the transfer of technology consistent with strategic needs."
3. "It must provide the means for economical management of IS resources and give necessary information for investment decisions. This requires development of both standards of performance measures and the means to evaluate performance against those measures to ensure productivity is being achieved. It should help facilitate make-or-buy decisions."

The management control system must not be limited to only financial controls but should include such things as surveys of user attitudes about the IS support provided, personnel turnover trends, measures of operational service levels (network uptime, job re-runs, response time, transactions processed, etc.) and reports on the status and development of projects.

## B. ORGANIZATIONAL VS. INFORMATION RESOURCE PLANNING

Information resource planning and organizational planning should be compatible in most respects. There will however be differences, especially in the area of planning time horizons for the organization and the data center, user planning requiremnets and planning inputs, and evaluation by economic analysis of future plans.

1. Organizational Plans vs. Information Resource Plans

Ideally, both organizational planning and control system and information resource planning and control system will be on multiyear plans. The conflict occurs however when the organizational planning is keyed to the annual budget on a short-term basis and the information resource planning is linked to project life-cycle management. The project life-cycle can easily take more than three years with as much as a year to finalize the design approach [Ref. 43]. The data center manager must therefore extend the planning horizon to at least a three-year view to ensure adequate resources are available to support the organizational strategy.

The key to resolving the planning time horizon problem lies in the data center manager's involvement in the formulation and execution of the organizational planning and control process. The data center manager must be aware of, and provide substantive inputs to the overall organizational planning in three key management areas:

a) The data center planning and project life-cycle management effort must "systematically and precisely identify alternative steps for providing necessary services" [Ref. 44]. In addition to being responsive to changing organizational goals, the data center management must be responsive to changing organizational plans that are brought about by budgetary constraints. This can best be done by knowing the overall organization's control system and the "scoreboard" upon which organizational operations are based. For instance, if the organization is constrained by quarterly operating budget funds, then the data center manager must be prepared to initiate innovative operating plans to

meet the service requirements of a user at a cost that will be within the financial constraints of the budget. The user and data center management may have to alter the time the services are to be performed to take advantage of "idle" demand pricing, change the pricing scheme or divert/postpone other services until the financial constraints are eased. In any event the data center management must remain flexible and sensitive to the problems and requirements of the users of the data center's services.

b) Data center management must be aware of how the data center's management control system fits into the organizational management control system. If one of the organization's performance measures is inventory management, then the data center should have a performance measure that specifically addresses how the data center operations are supporting the inventory management system. The data center should be able to provide statistical data on such things as number of line items issued, amount and number of interdepartmental billings and the cost of running the inventory management system. Where differences exist in the organizational and data center management control systems, the data center manager must be able to reconcile these differences and have some knowledge as to the effects these differences may have in achieving the long-term strategic goals of the organization.

c) There is a dichotomy between the issues of control and innovation. The control issue normally encompasses comparison of actual expenditures to the budget and measurement of actual performance

versus planned. Innovation on the other hand involves experimentation with new technologies, emergence of new user applications and a willingness to try new or unproven techniques. If there is agreement on the balance of innovation and control at the organizational level and the data center level, then little conflict is present. If, however, there is a difference, whether organizational management or data center management supporting control versus innovation, the difference must be resolved. Generally, the impetus for innovation will come from users with new applications request.

The data center management control system must address the legitimacy of new applications and provide a framework of integrating the new applications into the data center operations if the request can be reasonably implemented. The data center management control system must be formulated with a sense for the organizational committment to control or innovation. If the organization's position is one primarily of control, then the data center management control system must be oriented to evaluate the new applications in strict cost-benefit terms and will have a major impact on whether the application is implemented. If the organization is innovation-inclined then the evaluation of a new application may be a process where the cost of the new application is documented by the data center's control system but the decision to implement the new application is a subjective determination. The data center management control system, therefore, has to support the organizational balance between control and innovation.

2. User Involvement

There can be significant conflict between the data center's planning scheme and that of the users. The users, whether or not a part of the formal organization, have a dramatic impact on the future of the data center. As discussed earlier, reconcilation of innovation and control between the user's requirements or requests and the services provided by the data center can be of pivotal importance. At the heart of the user/data center interface is the control issue. The user is often driven to focus on the solution to short-term problems where the data center may be concentrating on new technological advancements, long-term resource utilization and an orderly development of resources to meet long-term requirements. Cash [Ref. 45] suggests that this facet of the control issue can lead to "tension between IS dominance and user dominance in the retention of development skills and also in the active selection of priorities."

There are many reasons users may wish to exert a dominant role in the control of their computing applications. If the data processing center has a backlog of development of new applications, the user may wish to seek alternative sources for development of new applications. The proliferation of stand-alone computer systems and off-the-shelf software make an attractive solution to the users requirements when compared to the relatively long lead-time response of the data center. The user may see stand-alone systems as a means to gain control over the daily operations, maintenance and development priorities. Cash [Ref. 46] refers to these user-oriented measures as "short-term user driven" pressures toward user dominance. Conversely, Cash has identified some pressures that drive the data center toward dominance of control [Ref. 47]

a) "Staff Professionalism;
   i) ...provides an opportunity to attract and keep challenged, specialized technical individuals.
   ii) ... easier to develop and enforce better standards of IS management practice in a large group.
   iii) Lacking practical systems design experience and purchased software standards, the user often ignores normal data control procedures, documentation standards, and conventional costing practices."

b) "Feasibility Study Concerns; ... user-driven feasibility study may contain some major technical mistakes, resulting in the computer system being inadequate to handle growing processing requirements ...".

c) Organizational "Data Base System; ... collection of files at a central location for reference by multiple users ...".

d) "Fit to (Organizational) Structure and Strategy; ... centrally directed planning and operational control ...".

e) "Cost Analysis; A significant edge that a centralized IS group has, through their practical experience in other system efforts, is the ability to produce a realistic software development estimate which takes into account the interests of the (organization) as a whole."

Figure 2.1, excerpts from [Ref. 48], illustrate some consequences of either excessive data center or excessive user domination:

| IS | USER |
| --- | --- |
| Too much emphasis on data base hygiene | Too much emphasis on problem focus |
| New systems always must fit data structure of existing system. | IS says out of control |
| All requests for service require system study with benefit identification | Explosive growth in number of new systems and staff |
| Standardization dominates --few exceptions. | Lack of standardization and control over data hygiene and system. |
| IS designs/constructs everything. | Hard evidence of benefits does not exist. |
| Study always shows construction costs less than outside purchase. | User buying design/construction/maintenance services and even operation services from outside. |
| IS specializing in in technical frontiers not user-oriented markets. | User building networks to own needs |
| IS spending 80% on maintenance, 20% on development. | No coordinated effort for technology transfer or learning from experience between users. |
| IS thinks they are in control of all. | Communications costs are rising dramatically through redundancy. |
| Users express unhappiness. | |
| No strong user group exists. | |
| General management not involved but concerned. | |

Figure 2.1 Possible Implications of Excess Dominance.

For instance, if there is IS dominance then there will be too much emphasis on data base hygiene at the expense of user innovation. If there is user dominance then there may be a lack of standardization which could hamper system integration or maintenance.

A clear definition of user and data center responsibilities can help alleviate some of the conflict between users and the data center in establishing computing service policies. The following is a representative list of respective functions needed in development of new applications [Ref. 49]

a) "IS (data center) Responsibilities;
   i) "Developmnet of procedures to ensure that ... a comparison is made of internal development versus purchase...".
   ii) "Maintenance of an inventory of installed or planned-to-be installed information services."
   iii) "Development and maintenance of a set of standards which establish:
      - Mandatory communication standards.
      - Standard languages for classes of acquired equipment.
      - Documentation procedures for different types of systems.
      - Corporate (organizational) data dictionary with clear definitions for when elements must be included. Identification of file maintenance standards and procedures.
      - Examination procedure for systems developed as independent islands to ensure that they do not conflict with corporate (organizational) needs and that any necessary interfaces are constructed.

iv) Identification and provision of appropriate IS development-staff career paths throughout the organization.

v) Preparation of a detailed checklist of questions to be answered in any hardware/software acquisition to ensure that relevant technical and managerial issues are raised ... ".

- How proposed system meets communication standards?
- For word processing systems, upward growth potential, built-in communication and data processing capabilities.
- For data processing systems, availability of languages which support systems growth potential and available word processing features.
- For communication systems, the types of data transfer capabilities, list of available services, storage capacity, etc.

vi) Establishment of education programs for potential users ...

vii) An ongoing review of which systems are not feasible to manage and which should be redesigned."

b) "User Responsibilities;

i) Maintain a financial control system of all user IS-type activities.

ii) Make an appraisal of the user-people investment for each new (application), in both the short-term and long-term, to ensure a satisfactory service.

iii) Develop a comprehensive user support plan for (applications) that will support vital aspects of the (organization) or that will grow in use.

iv) Manage the IS/user interface consistently with its strategic relevance, as an integral aspect of the (organization).

v) Perform periodic audits on the appropriateness of system reliability standards, communication services, and security requirement documentation."

These responsibilities can assist the user and data center manager in determining their respective roles in the long-range and short-range planning of new applications and resource utilization. Both user and data center management have an obligation to fulfill these requirements if the pitfalls of user dominance or data center dominance shown in figure 2.1 are to be avoided.

3. Economic Analysis

"Economic analysis is a systematic approach to evaluating the relative worth of proposed projects" [Ref. 50]. As an integral part of planning, the examination of the costs, benefits and uncertainities of a proposal make economic analysis a tool in evaluating the economic consequences of a present plan or the appropriate course of action to follow in the future. Economic analysis provides an input to a decision-making process by indicating how to get the most for the resources expended versus the least expensive solution.

The data processing center manager can use economic analysis techniques as a valuable tool in evaluation, control, and make-or-buy decisions for new projects and new applications. As an evaluation tool, economic analysis can provide a mechanism for comparison of new applications with the alternatives in a standardized method. Without some standardized comparison criteria the alternatives, whether it be in-house development of software or whether or not an

alternative is in fact economically feasible, can be biased. The evaluation of new projects or new applications is difficult given that each application will have varying benefits, costs, life-cycles, and will have a different impact on the resource system as a whole. Economic analysis techniques can provide a common basis upon which the data processing center can base an evaluation of a project. Again, user involvement is a key ingredient in the formulation of the economic analysis. The user is in a position to know the benefits of new applications but the user must be educated, depending of course on the sophistication of the user, on how best to state those benefits in measurable[1] terms that can be incorporated into an economic analysis methodology. The user must also be familiar with the economic analysis techniques themselves so that they will have an appreciation for the value of economic analysis in life-cycle planning and decision-making.

There is a complex interface between the economic analysis of new projects and the management control system. In fact, "any economic analysis is done in context of the control system" [Ref. 51]. For instance, if the control system includes a chargeback scheme, then the economic analysis should include an examination of the transfer prices. Likewise, the period over which the economic analysis is based, the economic life, should be the same as the life-cycle of the project. When the interface between the economic analysis of a project and the management control system is in the analysis, the alternatives can be more readily compared in common terms and will facilitate the incorporation of the new project into the management control system. There are of course instances where new projects will have characteristics that can not be put in terms

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[1]In an economic sense.

common to an economic analysis methodology and the management control system. For instance, a software monitor may be dependent on a specific hardware configuration which has a life-cycle of eight years. The software monitor's life-cycle in terms of utilization by the management control system may be a much longer period. The inconsistency must be resolved, but more importantly, the difference will have to be considered in the planning of the management control system for the future. The economic analysis process itself is a complex and expensive endeavor that may not be justified for projects whose costs do not exceed the historical cost of conducting the economic analysis. It can however, provide a valuable input on the decision of how to or whether to develop and implement a large, new service project. The economic analysis procedure recommended by Zimmerman [Ref. 52] consists of six key elements:

a) "Establish and define the goal or objective. It should reflect a totally unbiased point of view concerning the method of solving the problem."
b) "Formulate appropriate assumptions. Assumptions are explict statements used to describe the present and future environment upon which the economic analysis is based."
c) "Search out alternatives for accomplishing the objective. Identify all feasible means of meeting the objective."
d) "Determine the costs (inputs) and the benefits (output) of each alternative. This is usually the most difficult and time-consuming step."
e) "Test the sensitivity of the analysis outcome to major uncertainties."

The user's request for a new application or project is usually identified on some form of "information service request" or "project request". The user's input into the

economic analysis of a project or application is "anticipated benefits" or "costs savings". These benefits and costs savings should be expressed as much as possible in quantifiable terms. A common pitfall is to confuse benefits with cost savings. The economic analysis should consider benefits and costs savings in the appropriate economic analysis methodology. A particularly difficult problem associated with economic analysis is the estimation of software costs. There are many software cost estimation models available that can be used if the new application meets specific parameters. It has been suggested [Ref. 53] that a more reasonable approach to software cost analysis is to compare common elements of the new application to applications that have been implemented in the past. This of course is dependent upon the availability of past project cost data. Figure 2.2 lists some of the project cost data that may be useful in developing an in-house model of project cost estimation.

There is a significant trade-off in requiring the preceding economic analysis techniques to be calculated if the process discourages creativity and user program innovation. The data center must decide if and how to employ these economic analysis techniques and must consider;

a) The data center's current hardware capacity and programmer availability.
b) The impact on user's requests.
c) How quantifiable are the benefits and costs of a project.
d) Does the benefit of the economic analysis outweigh the costs.

The management control system must address how the data center will evaluate and control the emergence of new applications. The role of the management control system in the task of evaluating the economic feasibility of projects

- Project Name
  - Description of major functions
    - Lines of code
    - Relative complexity on scale 1 to 10
    - Effort (man-months)
    - Development time (months)
    - Number of people
- Project cost
- Totals for major functions
- Documentation ( number of pages )
- Total staff
- Tools used ( hardware and software )
- Maintenance record to date
- Programmer productivity
  - Lines of project code per week
  - Hours spent in library updating
  - Hours spent on non-project work

**Figure 2.2 Project Cost Data Elements.**

is in the collection of data for comparison of key elements of new project proposals to similar projects in the past. The management control system can control the growth of new applications by requiring cost/benefit analysis of major new projects and provide the user with an opportunity to decide whether or not the new application is worth the investment.

## III. ELEMENTS OF A CONTROL SYSTEM

The control system, when referring to it strictly in the managerial sense without regard to specific controls for a computer facility, can be viewed simplistically as the set of processes through which organizations ensure that actual activities conform to planned activities. Within this frame of reference Stoner [Ref. 54] has identified four elements of a control system: (1) the establishment of standards and measures; (2) the measurement of performance; (3) the comparison of performance against standards; and (4) the taking of corrective action.

The nature of a computing facility's operations, however, requires a more comprehensive view owing to some unique characteristics. Consideration must be given to the effect of costing schemes or the degree of centralization versus decentralization in the organization. Decentralization will allow an organization to have decision making done at the lowest possible level as opposed to a centralized structure which may not include lower level management. The relationship between performance measurement and goal congruency has an effect on the type of control system that can be used. Ouchi's paradym [Ref. 55] discusses two fundamental questions in determining the appropriate form of management control; "the clarity with which performance can be assessed" and the "degree of goal incongruence". Ouchi states that a high level of goal incongruence can be tolerated where performance can be measured with precision. Where performance is qualitative in nature, the goal congruence of all personnel becomes vitally important.

The role of the management control system in a computing organization will be influenced by the stage of technological growth as proposed by Nolan [Ref. 56]. As the organization passes through each of the four stages: initiation, contagion, integration, and control; the management control system takes on a more active role. "At one time it is necessary to relax and let the organization search for effectiveness while at another it is necessary to test efficiency to maintain control" [Ref. 57]. Other recurring themes that appear in the literature on computing facility control systems are the relationship of the standards of performance and the organizational goals and objectives, the prioritization of jobs, or the use of management reports as an element of the control system.

Stoner's list of elements of a control system can be expanded to incorporate the more specific and unique requirements of a control system for a computer facility. The elements of a management control system are:

a) the centralized or decentralized organization and its relatioship with the control system
b) the costing schemes
c) the development/review of standards compatible with organizational objectives
d) the measures of performance
e) the comparison of performance to standards
f) the prioritization of jobs
g) the management reports
h) the taking of corrective actions

## A. ORGANIZATIONAL STRUCTURE AND THE CONTROL SYSTEM

The control system can cause the organization to be more centralized or less centralized depending on where the control system fits into the organization. Top-level

management can manipulate the control system to take advantage of the speed and flexibility of the system to bring the decision process to the front office and eliminate dependence on subordinates for judgemental and experience inputs. However, the control system is best implemented in support of a decentralized organization providing a basis for the projection of decision-making down to the lowest management level. If the control system is a tool for department heads, it can provide lower level managers with information to make more effective decisions and provide an opportunity for enhancement of creativeness and adaptiveness of lower level management. It will also allow upper management to assign authority and responsibility for decision-making at the lowest levels. Exactly how the management control system functions in a completely centralized, completely decentralized, or distributed processing data center organization will be discussed later.

## E. COSTING SCHEMES

Charging internally for the use of central computer facilities is becoming a common organizational practice. "The decision to impose a charging system, whereby a previously free service is converted into one for which users are charged, fundamentally alters the relationship between the user and the computer facility. A chargeback policy can play a major role in promoting effective and efficient utilization of scarce computing resources" [Ref. 58]. In practice, however, charging all too often fails to have significant beneficial impact, and can be a source of tensions and user dissatisfaction [Ref. 59]. Chargeback systems are most likely to be successful when they are based on an understanding of the purposes underlying the charging system [Ref. 60].

A chargeback system, like any management control tool, must be designed in relation to the particular situation involved. The nature of its computing activities, the sophistication of its users, and other factors unique to that organization will determine the chargeback system features best suited to a particular organization. Most significantly, the design of the chargeback system must reflect management's objectives in controlling computing activities and what role management wishes charging to play in the control process. Management's objectives in charging for computer services may vary from one organization to another, however, the primary objectives are typically all related in some way to control of the organization's computing activities.

Another significant factor in the design of a chargeback system is the ability to measure either output or process. The feasibility to measure desired performance with reasonable precision is an essential element underlying the structure of the chargeback system. [Ref. 61]. The user's perception of validity and fairness in the chargeback system will depend on the selection of measurement criteria that are understandable and accurately reflect resource usage (BERNARD). When the assessment of measurable elements indicates that it is not possible to measure either process or outputs with any amount of accuracy or lack of ambiguity, a chargeback system may be inappropriate [Ref. 62].

The primary reasons for charging for a computer resource is based on a desire to recover costs, effectively allocate the computer resource or regulate the demand for the computing resource [Ref. 63]. A costing scheme must be selected to achieve an optimum of all three basic desires and be compatiable with the mechanism with which the costing will be controlled. The cost recovery aspect will provide performance (fiscal) data on service departments. Effective

allocation of the computer resource can be accomplished with a discriminating prioritization policy once there is a realization that the computer is a limited resource.

The organization's management must consider several aspects of the computing activities to be controlled. Operationally, the organization must ensure that the users are efficient and effective in their utilization of the computing resources. The computer facility itself should have incentive to operate efficiently and be responsive to user requirements. In an environment where users have free access to the computing resources, it may be desirable to limit total demand for these resources to the available capacity and to minimize the problems that can be caused by load fluctuations.

Bernard [Ref. 64] contends that charge-out systems consist of two interdependent components; a budgeting process and a pricing scheme. The budgeting process is the mechanism through which the organization plans the provisions of computing resources and determines their allocation. The pricing scheme measures and provides a basis for controlling users consumption of these resources.

Management's view of the role a charging system should play in the overall management control process of the computer facility will determine what functions are performed by any particular charging system. The functions will also depend on how well the charging system is designed to effectively carry out its intended role. Some of the functions a charging system can provide are listed below [Ref. 65].

a) Provide management information for resource control and decision-making.
b) Provide a means of allocating resources among users.
c) Encourage users to employ computing resources effectively and efficiently.

d) Promote effective and efficient provision of services by the computer facility.

e) Permit decentralization of control over resource allocation decisions.

To be fully effective, a charging system needs to be tailored to the objectives it is to serve as defined by management. Charging is all too often regarded as an accounting mechanism, rather than a control tool that can be tailored to management's needs. While the main purpose of equitable cost allocation is certainly one of the functions of a charging system; it also ensures that computing costs are utilized in management information used for evaluation and decision-making. Viewing charging purely as a cost mechanism fails to recognize that charges have a direct influence on user attitudes, behavior, and decisions. The main motivation behind a charging system, therefore, is to control computing activities through this user influence.

## C. DEVELOPMENT OF STANDARDS

Performance standards are statements of what should be done to meet the organization's objectives. They are expressed in terms that permit determination of whether a certain measure of performance has been reached. Performance standards are set at each level of the organization and should be comprehensive in addressing the contribution that is expected of each level of management in the achievement of the organizational goals.

Performance standards must be precise and communicated to appropriate levels of management. Since different organizational groups will have different functions and contribute in various ways to the organization, the standards for each organizational group must be formulated such that there is no conflict between groups. In other words,

the performance measure of one group should not be at at the expense of the performance of another group. Each standard should relate to a specific organizational goal. Once standards are set, there must be continual review to ensure that the validity of the standard and performance level required by the standard is consistent with the progress toward the goals and objectives. The standards should be challenging but attainable.

The selection of standards is a difficult task. The performance task must be analyzed to determine what steps are involved, what parameters can be measured, and the impact of specific variables on that task. The standards should not only be an indicator of variant performance, but should also be a deterrent to performance that is below what is expected in that task. Like most aspects of control, the selection of an appropriate standard involves evaluation of the benefit to monitor a certain performance level and the cost, usually in overhead, to obtain the performance information. There can be a tradeoff in selection of the "best" performance characteristic to set as a standard and the one which can be measured more economically.

## D. MEASURES OF PERFORMANCE

The monitoring of computer system performance is necessary to ensure that surprises do not occur that may lower overall effectiveness [Ref. 66]. "Performance measurements should be conducted in pursuit of some specific and achievable goals" [Ref. 67]. The measurement process itself is central to the operation of a control system and is a necessary condition for control to occur [Ref. 68]. What is measured, however, is rarely performance per se but some specific attribute related to performance. The users of systems interact with the systems directly, but the data

describing the system relates to attributes or an extention of the system and not the system itself. The choice of measurements or attributes to be measured is therefore a significant decision.

The three fundamental frameworks of market, bureaucracy or clan discussed earlier are specifically delineated by the ability to measure either outputs, processes, or social indicators [Ref. 69]. This fundamental issue of assessing which performance attributes are feasible to precisely and accurately measure, forms the foundation for determining the performance measures and ultimately the management control system. The significance of identifying the proper attributes is argued by Euske when he says, "apparently well designed systems can produce undesired results because of a poor choice of the attributes measured" [Ref. 70].

Performance measurement provides the quantitative and qualitative information that is needed for carrying out all the functions of a control system [Ref. 71]. Euske advocates a five step plan in developing the system for performance measurement:

a) Identify the purpose for the measurement.
b) Identify the relevent feasible attributes to be measured.
c) Evaluate the measurements in terms of validity, reliability and meaningfulness.
d) If the evaluation in step 3 proves inadequate, develop a new system.
e) Evaluate the cost and relevance of the measurement system.

Three terms that deserve explanation with their relevance to measurement are meanfulness, validity and reliability. To be meaningful, a measurement must be understandable from the perspective of the user and it must not exceed the limitations of the data [Ref. 72]. Validity

deals with degree of similarity between the relations among the numbers chosen to express the measurement and the actual relations of the quantities measured [Ref. 73]. Reliability relates to accuracy in the sense that repeated measurements display consistency when measuring the same attribute [Ref. 74].

Timeliness of information is also a significant consideration. "For management control, data must be available shortly after the event" [Ref. 75]. Timeliness, in this sense, is not the equivalent of speed, but rather is related to the time span of the task. "Shortly", therefore becomes a timeframe within which management analysis and corrective actions can be taken. For management control system purposes a timely, but less accurate, measurement is often preferable to an accurate, but less timely measure [Ref. 76].

How an organization measures its performance is as diverse as the types of organizations. Tightly coupled with the standards of performance, the measurements of performance often involves the tedious task of quantifying a subjective evaluation of performance. If indeed it is necessary to do so, (ie, when using the computer resource to accumulate performance data) then the measurement must be free from factors that are outside the control of the responsibility center. For instance, if a measurement of programmer performance is "quality", then the term quality should be defined in terms that reflect the actual amount of time the job took to compile or job run-time once it was in the system vice job turnaround time which could be affected by the job priority, queueing algorithm, or other factors outside of the programmer's control. The measures of performance must be chosen to provide prevention rather than correction of deviations to the greatest extent possible. Of course, the single most important aspect of measurement

is that it must be capable of being compared to the standards. If the standards and measurements are not compatible, the exercise is futile.

## E. COMPARISON OF PERFORMANCE TO STANDARDS

The comparison of performance to standards is made to find areas in which the achieved output is not consistent with the desired output. More importantly, the comparison should provide an indication of "why" there is a variance, its impact on the achievement of the goals, and what corrective action should be taken to correct the discrepancy. In the comparison and evaluation process, the manager must ascertain the significance of the variance and whether the variance is a result of temporary conditions or the result of on-going sub-standard performance.

With standards constructed in such a way as to be quantifiable and valid measures of performance, the comparison is reduced to a relatively simple process. The difficult aspect of the comparison is the interpretation and evaluation of the reported data. Regardless of how quantitative the results of the comparison are, the manager must make some decision on whether the results represent a real problem, the significance of the variation, and how best to decide what to do. These decisions should not be made in a vacuum of input. The comparison should be the catalyst for the manager to initiate further investigation. This investigation should involve those persons who control the performance in question to get an insight as to the possible causes of the performance variation and solicit recommendations as to how to resolve the problem. When the persons responsible for meeting the performance standards are involved in the setting of the standards and collection, analysis, interpretation, and evaluation of the comparison

data, they will be more likely to be committed to meeting the standards. If they are part of the decision process on what corrective actions should be taken, the implementation of the corrective action will be more successful than an organizational decree from the "boss".

## F. PRIORITIZATION OF JOBS

Of the many resources the computer center manager must optimize, one of the most critical is the physical utilization of the computer. Two important aspects of managing the utilization of the information resource is controlling of when the user's jobs arrive at the computer and when the jobs are run. Axlerod [Ref. 77] uses the terms "macrosequencing" to mean "the process by which the sequence in which jobs arrive at the computer center is effected" and "microsequencing" to mean "determine the sequence in which jobs that have arrived at the computer center for service are run."

The user is a dominant figure in the management of computing resource problems. He must be "induced to use available computing facilities in a manner consistent with the organization's objective of maximizing the net value of all computer jobs run. This objective is achieved by central control through the use of budgetary control, pricing rules, and priority classification" [Ref. 78]. The user's budget and control through pricing are two financial control mechanisms discussed by Axlerod [Ref. 79].

The role of the user budget in computer utilization is to induce users to maximize the long-run net value of the computing for the organization as a whole [Ref. 80]. "The user's budget determines the upper limit of the quantity of computing resources that can be purchased subject to a given price and priority structures" [Ref. 81]. When the user

population is outside of the formal data center organization, the quantity of computing resources available to the user is constrained by the size of the user's budget and the cost of the computing service. Since the data processing center will have no effect on the user's budget size the computer center manager must be sensitive to the effect that the cost of the service will have on user demand. If the user is in the internal computer center organization, the computer center manager can "manipulate user demands by adjusting the total user budget and/or the capacity of the facility" [Ref. 82]. Budget limitations can be a significant factor in control of the user's demand for computing services. Associated with the budgetary limitations are the effects on demand that are caused by the prices set for computing services.

Axlerod states that the "primary purpose of pricing in (pricing control) is its role in allocating the demand for computing effectively." The pricing scheme must be made in conjunction with the characteristics of the user's budget. If for instance, the user is external of the computer organization with a fixed computer budget, the pricing scheme must take into account if the user has a choice of internal or external computing services. In this case, market prices may well dictate the pricing scheme the Navy computer center uses. Typically user's are deterred by high costs of peak-load services in a peak-load pricing scheme. This illustrates the processing control that can be gained by using various pricing schemes. Axlerod [Ref. 83] states that "the individual user's maximization behavior typically will lead to suboptimization of the whole system. The role of the controls instigated by central control is to induce individual users to maximize the utility of the system while maximizing their own utilities, subject to the imposed constraints" [Ref. 84].

The user has significant impact on the demand of computer resources. The data center manager can use many control measures to regulate the demand for the "scarce" computing resource. "Some are direct rules (e.g., certain jobs may be restricted to given times); some are less direct, leaving some discretionary power in the hands of users (e.g., a flexible budget-pricing scheme); while others combine direct and indirect means (e.g., a priority-pricing scheme may combine the restrictiveness of priorities with the flexibility of pricing)" [Ref. 85]. In a priority-pricing scheme different priorities are charged at different rates. "The users are allowed to purchase any level of priority that they desire and can afford. Control can be applied through budgetary manipulation (if user is within the computer center organization), variation in the price-priority relationships, and price levels" [Ref. 86]. Axlerod proposes that the "microsequencing" process can be thought of in terms of 3 categories:

a) Time Dependent Jobs: based on specific time parameters of the computer system, such as the arrival times of jobs and the time spent awaiting service. Many scheduling algorithms (e.g., First-Come-First Serve, Last-In-First-Out, Random Service) are available to data center managers to optimize resource utilization when job values can be determined.

b) Parameter Dependent Jobs; "jobs are sequenced according to one or more of their physical attributes, such as job size, job type" [Ref. 87]. Examples of algorithms to deal with optimizing these types of jobs are:

   i) Shortest-Job-First; "of jobs in queue, the job with the shortest processing time is the first to be run when the service station becomes available" [Ref. 88].

ii) Longest-Job-First; "of the jobs in queue, the job with the longest run time is the first to be run" [Ref. 89].

c) Value-Oriented Jobs; jobs are sequenced according to a priority assigned. Axlerod [Ref. 90] proposes four categories of value-oriented jobs:

a) Priorities based on job value; "the net value assigned may depend on tangible parameters, such as the mean and variance of the turnaround-time distribution and it may include more obscure factors, such as inconvenience and aggravation" [Ref. 91].

b) Priorities based on user status; jobs are grouped into categories that are determined by the type of user submitting the job. For instance, in a Navy Supply Center, requisition processing may have a higher priority than inventory reordering.

c) Sequencing with preemption; jobs are preempted by other jobs with parameters of a higher priority.

d) Priced-based sequencing; the user is allowed to select the priority of the job where the higher priorities are available at higher prices. "The user's choice of priority will be based on the priority/price relationship, (available) funds, particular service needs, and the state of congestion of the system" [Ref. 92].

Fundamentally, the prioritization control problem depends on who sets the priorities. If the setting of priorities is performed by the data center staff or an automatic scheduler, then the desired control mechanism is internal to the data center organization and the goal of "maximizing the net value of all computer jobs" [Ref. 93] can be met by manipulating internal resources. If, however, the user determines priorities, a pricing scheme must be used to control the

resource utilization. Whatever method is used, priorities must be determined and cannot be left to chance. The management control system must be able to monitor the job prioritization function in terms of hardware performance (e.g., CPU utilization and input/output channel utilization), software performance (e.g., queue length and turnaround-time) or pricing (e.g., job billing and accounting) to provide the data center manager with information on the physical resource utilization.

## G. MANAGEMENT REPORTS

Data processing management, like any other management, must have adequate information for the decision-making process to initiate actions to reach the organization's goals. If the data center manager wishes to direct and control the activities of the organization and benefit from the resources of the computing facility, there must be a way to measure performance against a predetermined level of expectation and compare resource utilization to available capacity.

Management reports provide the vechicle for such comparisons. On the basis of management reports, managemnet decisions are made and actions are taken to align actual performance to expected performance. " Viewed from this perspective, management reports can be readily accepted as the backbone of management control" [Ref. 94]. Schaeffer [Ref. 95] suggest there are three questions relevant to obtaining adequate management reports:

1. "What information should be included? Information that indicates if the objectives of the organization are being met and information required to facilitate future planning should be included in the performance reports.

2. "What difficulties should be considered?" An improvement for one performance standard may be at the expense of other standards. An example cited by Schaeffer [Ref. 96] illustrates how a reduction of personnel cost may look favorable from the perspective of the personnel cost standard, but in reality the cost reduction is a factor of personnel turnover which is, of course, not a favorable indication at all. A second difficulty is that summary statistics may be very deceptive. An excellent performance value in one area may hide poor performance in another area.
3. "How should this information be presented?" To provide a comprehensive view of organizational performance, the reports should have the following characteristics:
   a) The reporting system should measure and evaluate all functions that contribute to attainment of the organizational goal.
   b) The reports should be tailored to specific functions and express performance in terms appropriate to that function.
   c) The reports should contrast related measures of performance in such a manner that may indicate cause and effect relationships. Schaeffer [Ref. 97] recommends the use of ratios to "stress the changing relationship between two factors that would not be apparent in isolated entries."
   d) The reports should be clear and concise. Summary reports should be used where appropriate and reports to higher level management should be in graphic form.
   e) The reports should measure performance against a predetermined standard.

f) The report timeframe should be broad enough to provide a historical background on which to base judgements of the performance.

g) The reports should address resource utilization versus available capacity.

h) The reports should be prepared in an appropriate periodicity to allow timely corrective action.

i) The reports should provide management with performance information to draw inferences on potential problems.

j) The reports should facilitate trend analysis for organizational planning.

The underlying theme of the previous management report characteristics is the organization's ability to measure specific outputs, and/or performance measurements. The absence of these concrete measures requires some measure of the "proper behavior" of the members of the organization.

As previously mentioned, there can be some organizational hierarchy considerations in the evaluation of performance. In addition to the traditional vertical hierarchial structure, there is also a horizontal structure of information flow [Ref. 98]. Since all organizational groups may not have access to relevant performance information, this horizontal flow of management reports must be accomodated. Thompson [Ref. 99] describes three types of task interdependence that influences the physical and organizational aspects of a computing facility's information processing technology:

1. Pooled; each group of the organization makes a discrete contribution to the system while acting relatively independent of one another. For example, an analyst working in the inventory application of the Uniform Automated Data Processing System (UADPS) evaluates and modifies this application independent

of what other analysts may be doing in another UADPS applications.

2. Sequential; one organizational group may generate outputs for use by one or many other organizational groups.
3. Reciprocal; tasks mutually interact. For example, an inventory control department generates a report identifying purchase request that are late being processed. This will key the purchasing department to follow-up and expedite purchasing action on the late requests.

In the vertical flow of management report information there are four organization levels:

1. Operating personnel who generate and distribute the management reports.
2. Operating managers whose functional responsibilities include monitoring, controlling, and directing the performance of their respective groups.
3. Data processing manager who acts as the computer center manager.
4. Commanding Officer[2] (or top management) who is responsible for directing and controlling the data center's integration into the overall organization.

Each organizational level needs management reports. Some management reports are common to all four organizational levels and some are explicitly appropriate for an individual organizational level. The reports appropriate for each level will be discussed in more detail Chapter 4.

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[2]Commanding Officer and data processing manager may be the same individual in some organizations.

## B. CORRECTIVE ACTION

Once the comparison and evaluation of actual performance to expected performance is made, the appropriate organizational level must decide whether or not any action is necessary. If actions is deemed necessary, it occurs in either a corrective action form or in the modification of either goals, standards or measurements of performance. Webber [Ref. 100] suggests that "management compares the expected and actual performance in order to decide about its status:

1. "Performance is in control; no action is necessary.
2. Performance is not in control; take corrective action
3. Performance is less than expected, but efforts seem satisfactory; investigate validity of the goals and modify them as necessary."

If corrective action or review of the goals and objectives are deemed appropriate, the manager must provide feedback to those components of the organization whose performance does not meet the expected standards. Where corrective actions is required, the feedback should be as timely as the performance monitoring process so that the corrective action can be initiated early. A pitfall associated with early feedback is what Webber [Ref. 101] refers to as "premature rapid response". The premature rapid response situation can occur when the measurement of performance is not a valid indicator of performance or the periodicity of the report is out of synchronization with the appropriate timeframe of the performance being measured. The conditions in which performance is measured must be defined. Unique timeframes and consideration for a certain set of conditions must be taken into account. For instance, if interactive terminal response time is measured during a period of high batch activity, the response time performance may well be below the standard. If the manager is not aware of the

environment in which the performance is measured, a premature response that directs corrective action may exacerbate the overall system performance. The desire for a timely correction of a variance and a decision to wait for further indication of problems must be balanced to avoid the overreaction syndrome [Ref. 102].

## IV. STEPS IN DEVELOPING A CONTROL SYSTEM

The management control system must be developed and maintained in an environment of adaptability to change. It must be adaptive to the rapid advances in hardware and software technology and account for the dynamic growth in the new program applications. The management control system must be the common denominator in evaluating the organization's progress toward achieving its goals and objectives and must take into account the coordination of resources external and internal to the organization. It must be set in a regulatory role, but at the same time be sensitive to the external factors, such as commercial competition, migration of skilled computer labor, and increasing user demand.

### A. ESTABLISH GOALS AND OBJECTIVES

The mechanism for making the organization's dreams and strategic plans meaningful to its personnel is the establishment and communication of its objectives. These objectives can be formulated in two categories; operational objectives and organizational objectives. The similarities between these two categories is in the overall goal of an optimum blend of efficiency and effectiveness.

Anthony [Ref. 103] distinguishes between goals and objectives in the following manner:

1. Goals; "a statement of intended output in the broadest terms. It is normally not related to a specific time period. The purpose of a statement of goals is to communicate top management's decisions about the aims and relative priorities of the organization and provide general guidance as to the

strategy that the organization is to follow." The goals should be stated as precisely as possible and only those predominant goals that are critical to the organization should be formalized. Anthony's [Ref. 104] stated purpose of goals, "... to communicate top management's decision about the aims...", seems to imply that the goals are set solely by top management. Effective goal-setting should include an input from all levels of the organization. If the various levels of an organization are in agreement with the stated organizational goals, an important criteria of goal realization (i.e., goal congruency) is attained. "Formally, goals originate from top level management and are influenced by the environment, but also goals are made all through the system, even to the bottom" [Ref. 105].

2. Objectives; "a specific result to be achieved within a specified time, usually one year or a few years. If feasible, an objective should be stated in measurable terms. An objective should be consistent with the goals of the organization." Anthony [Ref. 106] asserts that the statement of objectives is essential to the management control system because "an organization's effectiveness can be measured only if actual outputs are related to objectives."

There is a hierarchy of goals that corresponds closely to an organizational hierarchy. For instance, the command goal may be segregated into departmental goals that represent departmental expectations and contributions to the overall organizational goal. Likewise, organizational objectives can be supported by individual departmental objectives. Using Anthony's [Ref. 107] framework, here are some examples of data processing center goals and objectives:

1. COMMAND GENERAL GOAL 1. Increase productivity and cost effectiveness.

   a) Departmental specific goal 1-60-3: Improve statistical data gathering capabilities.

      i) Objectives:

         - Develop/obtain software by 1 September 1984 to provide computer system statistical data.
         - Refine capacity analysis report system techniques by 1 October 1984.

   b) Department specific goal 1-60-4: Reduce computer re-run time.

      i) Objectives:

         - Increase operator training (data entry) to once a week.
         - Increase number of applications run under automatic scheduler.

## B. SET POLICIES AND PROCEDURES

Once the specific goals and objectives have been formalized, the next step is to state in general terms top management's policy with regards to how to achieve those goals and objectives. Again a hierarchial flow of policy statements should emerge that are congruent and provide guidance to each subordinate level in the organization. Likewise, subordinate levels of management should make policy for levels of organization within their group. The construction of the policy structure must be supportive of the plans to achieve the goals of the organization and the policies should address the course of action each level of the organizaion should take to attain the appropriate objectives.

At each level of the organization the policies are refined to specific procedures. The procedures generally

state how the expectations of the organization can be met by detailing those specific actions that must be taken at an appropriate level in the organization. For instance, a policy for the input/output branch is to control job receipt and disbursements. The procedure for accomplishing this control may be to require positive identification by photograph and signatures of users receiving completed jobs. As can be seen from the preceding example, the management control process permeates the organization and operates on a continuum that starts with the definition of goals and objectives and proceeds to the development of specific actions to accomplish those goals.

## C. ORGANIZATIONAL STRUCTURE AND THE CONTROL SYSTEM

At the heart of the management control system is it's relationship with the organizational structure. The management control system will have a different role in the organization depending on whether the organization is centralized or decentralized. There are many arguments [Ref. 108] for both a centralized or decentralized data processing organization. Martin [Ref. 109] lists the following arguments relating to the centralization/decentralization questions:

1. "Total Costs
2. Technical arguments other than costs
3. Arguments relating to application development
4. Arguments relating to which applications should be centralized and which decentralized
5. Arguments involving (organizational) politics, the behavior of of people, or the impact on the human side of the (organization)."

Martin also states [Ref. 110] that "the best of both worlds can be achieved by a judicious mixture of centralized and

decentralized functions." The key to management control system's role in a centralized, or decentralized organization is whether operational data is available to compare the actual performance to the planned performance. This operational data, usually available as management reports, is the encapsulation of the other elements in a control system.

Figure 4.1, a modified version of a Boore and Murphy model [Ref. 111], illustrates the concept where decentralized units input operational data into a data base from which management reports can be extracted for the management

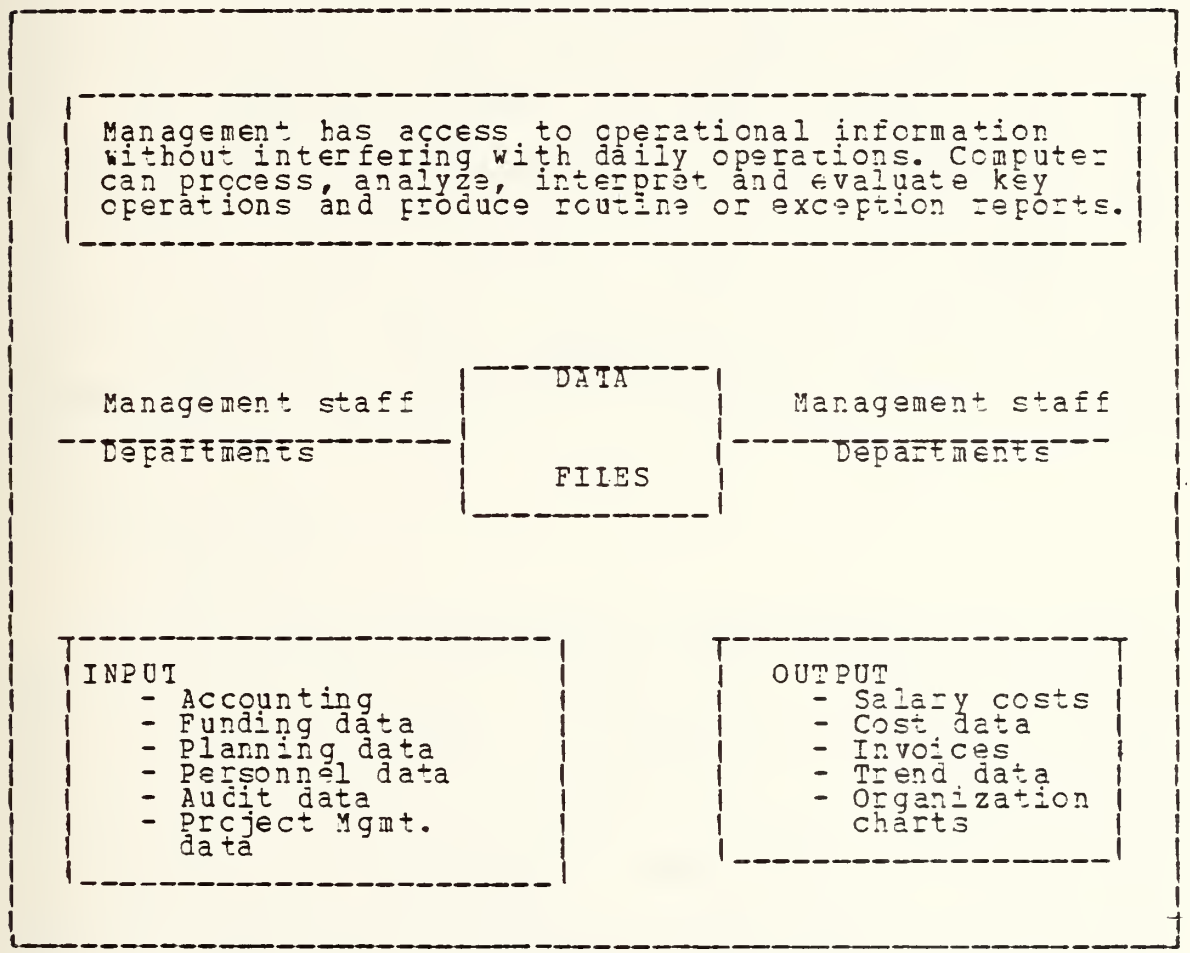


Figure 4.1 Use of Data by Management and Decentralized Units.

control system. This model, of course, assumes that the central computer resource and decentralized units are hardware and software compatible, ie., the files of the decentralized units are structured as subschemas of the centralized data base.

Since operatinal data is accessible to top management by data base query, some workers may fear that the data they input can be used to rate their personal performance. This could lead to a phenomenon where the input data may be exaggerated toward more favorable figures. Additionally, some personnel or departments may be reluctant to share their oprational secrets or developments with other grouups that could have access to their data. The key to this problem is for the appropriate groups to have access to the same reports as top level management in their respective area. In this way, the lower echelon levels can have the same data and can be taking corrective action or be prepared to discuss variances when the upper levels have questions about them. Regardless of the organizational structure, operational information must must be available to the management control system.

## D. SET STANDARDS

Once the organizational goals and objectives are formalized, a set of standards is developed to foster the attainment of those objectives. As previously defined, Ouchi [Ref. 112] suggests that an organization's control mechanism will be made up of a combination of a pure market, a pure bureaucracy, and a pure clan. Additionally, the organization will contain some features of each mode of control. In designing standards the computer center manager must assess the social and informational characteristics of each level of the organization and determine which form of control

should be used in each case. Ouchi [Ref. 113] suggests that the social characteristics involve such requirements as:

1. 1. Norm of reciprocity
2. 2. Legitimate authority
3. 3. Shared values and benefits

The informational characteristics that are keyed to the type of control are explicitly stated and maintained intentionally at some cost. The informational characteristics include: prices, rules, and traditions.

Brandon [Ref. 114] refers to standards as "performance standards" and defines them as "yardsticks". Standards are used to measure the performance of the data processing function" [Ref. 115]. Essentially, standards are "what should be accomplished (to achieve organizational objectives)" and "expectations by which satisfactory performance can be judged" [Ref. 116]. The standards must be valid characteristics of the organization and be of some use in monitoring the progress toward the organizational goal.

According to Schaeffer [Ref. 117], standards address the following questions concerning the organizational objectives:

1. "How will attainment of data center objectives be judged?"
2. "How will the data center be structured to meet these objectives?"
3. "How will adequacy of personnel career paths be judged?"
4. "How will adequate career paths be established?"
5. "How will effective budgeting be judged?"
6. "How will the budgeting be done?"

The development of the standards should be done in an order of precedency with the most important and urgent standards developed first. Typically, organizational structure standards are logically the first ones developed to provide a

framework for evaluation of the functions and workflow of the organization. Standards should be constructed in such a manner that not only provides empirical data but also facilitates analysis in terms of patterns, trends and indicators.

Schaeffer [Ref. 118] has classified standards into four general categories:

1. "Administrative standards; includes activity and performance reporting requirements.
2. Operations standards; includes workstation, workflow and data center performance.
3. Contingency standards; attends to varying degrees of emergencies including disaster plans.
4. Support service standards; includes data center relocation, equipment selection and documentation."

These classes of standards must address a variety of organizational issues. The standards must attempt to support the unique data processing objectives of the organization mentioned earlier, and also support the "continuing objectives for all organizations" identified by Webber [Ref. 119] These continuing objectives include:

1. Identification; "achieving staff consensus and commitment to organizational objectives."
2. Integration; "an overlap between personnel's personal objectives and the (organization's)."
3. Social influence; "a distribution of power and influence."
4. Collaboration; "a means of measuring human conflict within the organization."
5. Adaptation; "a monitoring of the external environment and responding appropriately internally."
6. Revitalization; "a development of personnel vitality and creativity."

The standards must be clear, concise, complete and well documented. The users must be involved in establishing and

later evaluating the standards so that the users understand not only the standards but also the logic for monitoring performance in that way. Failure to involve users in standard development may result in user dissatisfaction and cause a duplication of the standards development effort. User involvement in standards formulation will result in the selection of standards in such a way as to preclude introduction of variances that are beyond the control of the responsible center. There must be agreement between all levels of the data center organization and the users that the standards set:

1. Supports the attainment of organizational objectives
2. Are fair "yardsticks" to gauge the attainment of the objectives
3. Are valid indicators of the organization's objectives

## E. DETERMINE MEASURES OF PERFORMANCE

The question of how to measure performance is a complex one. The data center manager has to not only measure the performance of highly technical equipment, but also the performance of personnel and the degree to which the organizational structure supports the equipment and personnel. The measures of performance must address not only those parameters that can be measured quantitatively, but also those that must be assessed on a subjective basis.

Metrics, the measures by which things are evaluated, are relatively straightforward for quantifiable characteristics but not so accurate for qualitative areas. The metrics must be accurate, readily available, consistent, impartial and congruent with performance standards. The complexity of measuring performance is evident in the general purpose nature of the computer center operation. A Navy computer center will typically run more than one type of application

and determining the measures of performance to use for the hardware alone is difficult. For instance, should the performance measure be in terms of number of jobs processed? This ignores the problem of differential loads that various jobs place on the systems. The system resource utilization can be an alternative measure, but at times some of the systems resources have a higher utilization than others. The answer to the question of what performance parameters to evaluate must be made with inputs from all levels of the organization. What standards of performance are selected, how the organization is structured, whether the performance information can be collected, the costs and benefits of collecting the performance data, and whether or not measuring these performance parameters is useful in controlling the information resource (equipment, facilities, and personnel) must all be considered.

Quantifiable monitoring of the computer system performance can help isolate the portion of th system that is operating below performance standards. Some primary tools for collecting system performance data are:

1. Operating system accounting packages. These software tools are very capable in terms of collecting system performance but generally require additional overhead in terms of memory capacity.
2. Hardware monitors. Hardware monitors are userful in collecting performance data such as voltage fluctuations, hardware mechanical availability and hardware response times.
3. Software monitors. Software monitors are usually composed of two elements; one which collects program performance data and another that analyzes and reports the performance data.
4. Embedded system monitors. Data collection and reporting modules are designed into the applications.

Some quantitative system performance measures that may be of value to the various levels of the data center management are listed below:

1. Terminal response time
2. Transctions processed
3. Percentage of system availability
4. Records processed
5. Reports delivered
6. Communication line loading
7. CPU utilization versus availability
8. Number of program re-runs

Some quantitative organizational performance measures that may be of value are:

1. Budget reports
2. Overtime/staffing reports
3. System maintenance backlog
4. Training reports

The preceding reports can be categorized as budgetary, planning, resource utilization and allocation, and performance control reports.

Qualitative measures are more difficult to establish. In many cases qualitative measures of performance rely on subjective evaluation. Although there are many quantitative models to define reliability and productivity, users generally address reliability, usability, adaptiveness, productivity, effectiveness and innovation in qualitative terms. As Ouchi [Ref. 120] contends, the degree of qualitative or quantitative form of measurement involved in the definition of these types of terms will depend on the organization's technological sophistication and actual ability to measure attributes. Even when these terms are qualitative in nature and they can be correctly labelled vague and/or subject to ambiguity; the constraints of the systems inability to provide more accurate or quantitatively measurable attributes dictate their utility.

A data processing center typically operates as a service organization and as such is often constrained, at least in part, to qualitative evaluations based on user perceptions. The following computer service characteristics, although difficult to measure, will provide the user's perception of how well the data processing meets the user's needs [Ref. 12].

1. Service usefulness; Does service provide data required for user operations?
2. Service responsiveness; Is service performed in specified timeframe?
3. Service flexibility; Are unexpected requirements accomodated in a timely manner?
4. Service availability; Is service available when users need it?
5. Service reliability; Does service provide correct information in correct format?
6. Data processing center involvement in user requirements development; Is data processing center involved in establishing user data processing requirements?
7. Data processing center system maintenance support; Does data processing center provide timely hardware and software maintenance support?
8. Data center support of user's objectives; Does the data processing center understand and support the user's objectives.

These quality of service measurements are generally provided by the user satisfaction surveys. The information provided is often formulated on the user's perception of the service rather than statistical data.

The measurements of performance for the organization should not be limited to only budgetary items but should also include: organizational resources, such as personnel and communications; computing resources, such as CPU and

peripherals; administrative resources, such as clerical and reports; and managerial resources, such as long-range plans and investments.

## F. COMPARISON OF PERFORMANCE TO STANDARDS

Once a mechanism has been established to collect the appropriate measures of performance and the performance data is collected, it must be compared to the respective performance standards. This comparison is a three step process:

1. Analysis; a separation of the performance data into its parts to study its structure.
2. Interpretation; a definition of the meaning of the performance data.
3. Evaluation; the assessment of the actual operational and managerial conditions as compared to the expected performance set forth in the standards.

The comparison of performance to the desired standards should be done to determine the variance between actual and planned performance. The performance should be evaluated to analyze trend data and to compare relative change vice absolute change. Vital to the comparison process is the accurate recording of the performance data. The standards must be set at a level that is reasonably attainable. The bottom line comes in the evaluation of the comparison data. It must be viewed in the context of the accomplishment of the organizational objectives and the comparison process itself must be reviewed to ensure that the control system is monitoring those vital signs of the organization's activities that are in the mainstream of its future. The results of the comparison must then be a source of feedback for whatever corrective action is needed.

Where in the organizational structure the comparison of performance to standards is made is determined by the rela-

tive hierarchy of the measure of performance. For instance, if a measure of performance is "program re-runs due to operator error", the shift supervisor would be a more appropriate individual to monitor that particular performance criteria than the data center manager. Conversely, the trend data concerning the proliferation of new user applications is more appropriately monitored at the data center manager level. The evaluation of the management control system's monitoring of performance must not be strictly a top management responsibility. When the standards are set and the measures of performance defined, the analysis, interpretation and evaluation of the performance measures should be done by persons or groups of persons who can directly or indirectly influence the behavior of that particular performance. It may be appropriate that many organizational levels monitor specific performance measures. Computer program backlog is an example of a performance measurement that permeates all levels of a data center organization. Likewise, customer complaint trends affect the entire data center organization.

## G. MANAGEMENT REPORTS

The primary objective of management reports is to provide the top level of organizational management with the information necessary to direct and control the activities of the data processing center in its contribution to the overall goals and objectives of the organization. The management reports to top management must provide information in the following broad categories:

1. Existing problems and risks
2. Potential problems and risks
3. Accountability for each function, decision and project

4. Corrective actions, in progress or planned, to deal with existing or potential problems
5. Variances in meeting or exceeding performance standards
6. Benefits resulting from individual or group performance or decisions

These types of information should be presented to top level management in summary form, such as graphics, but with a clear, concise narrative that highlights the major points of interest in specific areas.

For discussion purposes, the organizational structure of a Navy computer center is assumed to be one in which there is a Naval Officer assigned as Commanding Officer (representing top management) to whom the data center manager, either civilian or military, reports. Reporting to the data center manager are departmental managers and organizationallly below the departmental managers are the operating personnel. With this organizational structure, the types of management reports will in some cases be the same (i.e., CPU utilization). But in other cases, the management reports will concentrate on the performance parameters appropriate to the specific level of responsibility and that organizational level.

The following management reports should be submitted to the Commanding Officer, addressing the six information categories previously discussed:

1. Budget Reports.

   Budget reports should display to the Commanding Officer a comparison of actual expenditures[3] to planned expenditures for the work accomplished for the data processing department and overall organiza-

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[3]Expenditures in this sense relates only to the concept of spending resources and does not make distinctions between obligations and expenses as defined by the Resource Management System (RMS) accounting practices.

tion. Narrative comments should be provided to discuss reasons for trends and variances. Budget reports should show departmental budget status with comments explaining any variances.

2. Resource Utilization Reports

a) Operations

i) Available CPU capacity versus capacity acutally used. This report should compare available CPU capacity with how the CPU was actually used by categories (e.g., running programs, downtime, reruns, preventive and remedial maintenance, and application development).

ii) Available storage capacity versus storage capacity used.

iii) Available data entry capacity versus capacity used.

iv) Overtime or extraordinary staffing requirements. This report will give indications of reaching staffing capacity limits and need for additional staff.

v) General comments on potential capacity limitations (hardware and personnel) and recommendations for change to increase organizational efficiency and effectiveness.

b) System Development and Maintenance

i) Backlog of system maintenance, new service requests and modification requests. The backlog should indicate by type of request the man-hours that will be needed to bring service requests to a current status. The average age of the requests should be indicated with the percentage of system maintenance staff that will be needed and the

predicted date that the backlog will be eliminated.

ii) Status of major projects indicating current status, progress and problems.

3. Performance Control Reports

a) Operations

i) Cost of recovery, CPU time and number of re-runs. This should be compared to the performance standard with comments to explain causes and corrective actions taken.

ii) On-line system response time. This should be a comparison of actual (averaged) response time to a predetermined standard. This report also gives an indication of support to the on-line users.

iii) Late reports. This is an indication of how many reports were delivered on time versus a standard.

iv) System down-time. A comparison of system down-time to a standard with narrative comments for reasons there is a variance.

b) System Development and Maintenance

i) Application performance and quality audits. The results of internal audits of application programs highlighting sub-standard performance.

ii) The costs attributed to project or application maintenance or modification.

iii) Percentage of projects completed on time. Also the percentage of maintenance and modification projects that were completed within estimated completion dates.

c) User Relations

i) User satisfaction survey. This report should quantitatively rate the data processing center's customer satisfaction.

4. Resource Allocation Reports

a) Cost justification for major data processing expenditures that have to be approved by top management.

b) Major proposals for new systems development. These are submitted for approval and priority assignment.

Additionally, annual reports should be submitted on problems or progress in the following areas:

1. Budget status
2. Major applications installed
3. Major organizational accomplishments
4. Contribution of the data processing center to the organization's goals.
5. Long-range plan updates, including objectives, plans and budget for the next year

Since the reports typically flow from the lower levels of the organization, the type of reports submitted to the data center manager address many of the same issues of concern to the Commanding Officer. Although the focus remains on problem areas, accountability, and corrective actions, increased attention is paid to planning factors and to the requirements of daily activities. The following management reports should be submitted to the data center manager:

1. Budget Reports

These reports compare actual expenditure to expected expenditures and should trigger questions to functional managers whose departments show unfavorable variances. Generally, purchase requisitions and personnel contract requests are submitted to this

level in the organization for approval. The status of facilities and service contracts are reported in the budget reports. Additionally, the current status and problems with user service agreements are reported with the expected impact on the budget.

2. Resource Utilization Reports

a) Operations

i) CPU utilization versus availability. Separate reports indicate rerun time, down-time, preventive and remedial maintenance time, and internal data processing application run time. User CPU utilization trends for remote job entry (RJE) and interactive applications should be prepared and percentage of mainframe CPU utilization for user on-line processing should be reported.

ii) Library status report. The status of the tape library back-up system, tape cleaning and verification, and disk compression should be reported to the data center manager. Problems in this critical area can cause extensive operational difficulties.

iii) On-line system availability. This report is of major concern to on-line users. The actual system availability should be compared to a standard and reasons for lack of availability stated.

iv) Computer hours used for program development and testing.

v) Staffing levels by shift to identify scheduling problems or document the need for increased or decreased operations, development, and maintenance personnel. If the workload can not be accomodated within the

specified standard (i.e., daily processing should be completed by the conclusion of the second shift), then more personnel, improved methods, or procedures may be indicated. Likewise, a decrease or reassignment of personnel may be indicated when the workload accomplished exceeds the standard. The report itself must be evaluated in terms of its marginal value to its marginal cost to decide if this performance measure contributes to the control of the organization.

vi) Deviations from budgeted operating costs or excessive expenditures on supplies should be reported as an exception report to alert the data manager to not only budget implications but also to underlying operational problems.

vii) Data entry use versus capacity available. Variances in data entry may indicate problems with personnel, hardware peripherals, software or environmental problems.

viii) Perpheral device utilization in terms of time and capacity should be reported for planning purposes. The percentage of channel capacity useage can be an important performance measure in determining if the system is operating in an input/output limited environment.

b) Systems Development and Maintenance

i) A backlog of development and maintenance work request showing the number, type, estimated workload (in hours), user, status and priority of requests.

ii) System development staff time worked versus total available time. This can be a measure of relative productivity.

iii) System development staff time worked by category (new system development, existing system modification or maintenance) in hours and as a percentage of staff time available.

iv) The maintenance and modification costs, in terms of hardware down-time and staff time, should be reported in hours and trends to identify applications or project candidates for replacement.

3. Performance Control Reports

a) Operations

i) A summary of re-runs by major application, showing frequency, machine time lost, cost of recovery and cause.

ii) A summary of the average time a job stays in queue and the average number of queues.

iii) A summary by application of reports delivered on time compared to a performance standard.

iv) Terminal response times in terms of averages and means to detect trends that may result in user complaints.

v) A summary of peripheral hardware failures to indicate reliability problems, plan for contingencies and monitor vendor maintenance performance.

vi) Telecommunication system up-time as compared to a performance standard.

vii) Transactions processed and cost per transaction.

viii) Status of training (formal and on-the-job) as compared to a standard.

b) Systems Development and Maintenance

i) Percentage of projects completed on time and completed within specified costs by project category.

ii) Average response time to a user's request with the period noted between reciept of request and start of actual work.

iii) Average turnaround time or program tests and compilations as a measure of operations support.

iv) Average number of compilations and test per program to indicate whether design techniques and tools are being used effectively.

In addition to the formal reporting structure the data processing manager should hold weekly staff meetings to augment the information received in the formal management reports.

The next level of the organizational reporting structure is the departmental managers. Typically, these individuals are managers of the data processing center's operations, systems development, programming, financial, supply and control groups. First line supervisors such as those that supervise data entry, controls, library and other functions may also be included. These "departmental managers" either generate the reports to higher management or are responsible for the production of these reports. This level of management is concerned with the following categories of information:

1. Individual performance evaluation
2. Allocation of personnel
3. Machine performance evaluation
4. Ensuring information validity

The department managers prepare reports for upper levels of the organization and therefore receive many of the same

reports. The following is a list of management reports used by the department managers that are unique to this level of the organization or are used for a unique function:

1. Resource Utilization Reports
   a) Operations
      i) CPU utilization reports used for initialting corrective action. Rescheduling of work and allocation of channels and memory can be enhanced by actions taken resulting from this report.
      ii) Remote systems reports on resources at outlying user locations can be used for contingency planning and job rescheduling.
   b) Systems Development and Maintenance
      i) Work request response time and backlog.
      ii) Personnel leave and availability schedules for workload planning.
2. Performance Control Reports
   a) Operations
      i) Computer evaluation reports such as job accounting logs, software monitors, and hardware monitor reports.
      ii) Reports that can be used to evaluate personnel performance such as:
         • Keystrokes
         • Error-rates
   b) System Development and Maintenance
      i) Project status reports and milestone completion reports can be used for evaluating development and maintenance personnel.
      ii) Documentation status reports can provide personnel evaluation information
      iii) Personnel evaluation reports provide department managers with a direct evaluation of their personnel.

Situational reports such as trouble reports, failure reports or problem reports are also received at the departmental level. Failure reporting and analyisis should be completed for all failures, including machines, programs, power supply, facilities, safety, and security. For instance, Naval Supply System Command's capacity analysis reporting system [Ref. 122] requires reporting of machine down-time, power failures, safety and security violations [Ref. 123].

A comprehensive management reporting system is essential for the direction and control of the data processing center. The management reporting system provides essential information to appropriate levels of management for planning, decision-making, and control of data processing.

## B. CORRECTIVE ACTION

As stated earlier, corrective action is the feedback mechanism to remedy an "error condition" that indicates the organization or a sub-group of the organization is not progressing sufficiently toward its goal. The decision to take corrective action will normally be made at a level of organization that is commensurate with the responsibility for that performance and how strategically important that performance is to the organizational goal. The process in deciding what, if anything, should be done about the variance in performance involves [Ref. 124],

1. Diagnosis of the problem with regard to its nature and causes and a statement of the requirements of a satisfactory solution. The constraints within which the corrective action must be made must also be identified.
2. Determination of alternative solutions "will range from doing nothing to finding a way out of the difficulty, removing the difficulty or even modifying the objective" [Ref. 125].

3. Analysis and comparison of alternatives to determine the advantages and disadvantages of each solution.
4. Selection of the corrective action alternative to be followed with identification of all significant consequences of that choice.

As discussed in Chapter 3, the timing of the corrective action is an important factor in how the system performance will react. Premature response or over-reaction can cause an uncontrolled oscillation in performance if the persons responsible for ordering corrective actions are not familiar with the sensitivity of a particular performance parameter to change and they do not know the effect a change in this performance measure may have on other performance parameters. If a manager reacts too soon to a performance measurement, the condition that gave an out of control indication may be worsened. For instance, if CPU idle time is above standards, the data processor manager may be inclined to run more jobs when in fact the job mix of input/output intensive jobs is the reason the CPU utilization is down. If the data processing manager waits too long to take corrective action, the condition may worsen to the extent that primary services to the customer are terminated. An example of not taking corrective action soon enough might be where a data entry clerk has a problem entering an inventory receipt and instead of the data entry supervisor calling in a trouble report, the data clerk continues to enter the data. Each time the data entry clerk keys the enter command the receipt information is queued and when the transaction is finally processed, multiple receipts of the same document are recorded. A solution to the over-reaction problem recommended by Webber [Ref. 126] is to monitor sensitive performance parameters on a continuous basis and respond with small corrections. This action, if appropriate to the specific performance parameter, should prevent costly premature response or over-reaction to a variance.

Equally important as the decision of what, if any, action should be done is the question of who should actually make the correction. The level of management that makes the decision to take corrective action must consider the following things in assigning the task:

1. Responsibility; Is the person(s) assigned to take the corrective action responsible for that particular performance standard? If there is joint responsibility, then all responsible parties should be advised.
2. Authority; Does the person tasked with making the corrective action have the line authority to make it happen?
3. System impact; Will the corrective action affect other performance parameters? If so, persons responsible for those performance parameters should be consulted.
4. Agreement; The corrective action should receive support from not only the decision-maker, but also those persons responsible for making the corrections.

There is no magic formula of how many variances constitute a performance problem or how long a manager should wait to determine if there is a problem. These are management decisions that must be guided by inputs from appropriate levels of the organization for each performance area and an appreciation of the entire system environment.

# V. EVALUATION GUIDE

## A. INTRODUCTION

There are many types of computing facilities within the Navy, and each one will have its own unique characteristics as well as vast operational differences. A NARDAC for example, with the computing facility being the Command itself, will function quite differently than a Data Processing Center at a Naval Supply Center. At a NARDAC, Command and Data Processing Center goals and objectives would be one in the same as would the roles of Commanding Officer and Data Processing Officer. A Data Processing Department at a Naval Supply Center, however, would have a hierarchical structure with broader Command goals and objectives which should be reflected in the subordinate department's more specific goals and objectives. While many fundamental similarities remain among computing facilities and their inherent requirements for control systems, the unique mission and operational requirements imbedded in each organization cause any attempt to generate an evaluation guide spanning these requirements to be necessarily general in nature.

This evaluation guide is focused on management control system issues as described in the previous chapters of this thesis. However, this guide is by no means intended to be a comprehensive document covering all aspects of a computing facility's operation in the detail an Insector General or audit team may desire. The intended purpose of this evaluation guide is to aid a data processing manager or prospective data processing manager in assessing the effectiveness and appropriatness of the management control system for a typical Navy computing facility.

This evaluation guide was developed within the scope of the issues and theories discussed in this thesis. Use of this guide should be tempered with a "big picture" assessment of the computing facility being evaluated in terms of technology, organizational structure, and stated mission.

The guide itself is conceptual in nature with many qualitative terms included that must be defined in a qualitative sense by the user. Additionally, many of the questions that are asked contain some elements that may appear to be mutually exclusive. Owing to the diverse nature of the types of computing facilities that this document could be used for, the thrust is to provoke questions that cover a broad range of issues. These issues can vary in their applicability from one facility to another and it is incumbent on the user to determine the applicability of each question.

Another key element in the proper use of this document is to develop a feel for the underlying characteristics of the organization being evaluated in terms of the management theories that influence management controls as presented in this study. Some of the major influences include the following:

1. Ouchi's framework for management control: The ability to measure either output, processes or neither will shape the control mechanisms in three fundamental frameworks called markets, bureaucracies, or clans.
2. Nolan's stages of technological growth: The stages which all data processing organizations go through are defined as initiation, contagion, integration, and control. Each stage will require a different form of management control.
3. Thompson's types of task interdependence: Three definitions of task interdependence which will influence organizational structure were defined as pooled, sequential, or reciprocal.

Tempered with a fundamental grasp of the organization's positions with respect to the themes and issues presented, the user is tasked to evaluate the management control system effectiveness in their own quantitative terms. The questions are intended to stimulate interest and investigation and evaluation of the areas covered.

## EVALUATION GUIDE

### B. ORGANIZATION

1. Is there a current chart of the Command's organizational structure down to the Data Processing Center level?
2. Is there a current chart of the Data Processing Center's organizational structure?
3. Is there a listing of key management personnel in the Command's chain-of-command from the Commanding Officer down through the Data Processing Center branch level?
4. Is organizational structure designed so there is no overlapping of functions, responsibility, or duplication of effort?
5. Is the existing centralization, or mixture of both satisfactory?
6. Are the functions , responsibilities, authority, and relationships of each significant position in the organization defined in writing?
7. Is there satisfactory rapport between management, staff and users?
8. Is the organizational structure in harmony with the objectives of the Command and the Data Processing Center?

9. Is authority so delegated as to permit decisions to be made at the lowest feasible levels of management?
10. Does the organizational structure provide for unity of command -- each person reporting to no more than one superior?

C. MISSION

1. Is the mission of the Command clearly stated?
2. Is the mission of the Data Processing Center clearly stated?

D. GOALS AND OBJECTIVES

1. Are Command goals and objectives set down in writing?
2. Are Data Processing Center goals and objectives set down in writing?
3. Is there consistency and continuity between Command goals and objectives and Data Processing Center goals and objectives?
4. Are goals and objectives measurable, attainable, comprehensive, and relevant to the Data Processing Center's needs?
5. Are goals and objectives reappraised periodically to ensure uniformity and congruency among organizational components?

E. OPERATIONS

1. Are decisions made at the lowest feasible level?
2. Is there a methodology to review tasking (or prioritization) versus resources?
3. What methods are used for cost allocation and measurement? Do they encourage effective use of the computer resource?

4. How are job priorities assigned? Is the priority linked to the job pricing scheme?
5. Has an approval system been implemented that:
   a) Has approval levels commensurate with the significance of the project?
   b) Reviews validity of the job?
   c) Determines job priority?
   d) provides coordination for jobs that span several departments?
6. Is there a conflict between management job prioritization and user job prioritization ( eg. user assigns a high priority to a long job but the system is running a "shortest job next" queueing algorithm )? Is there a procedure to resolve these conflicts?
7. Are there procedures to track the input and output of all jobs?
8. Are precomputer and postcomputer activities scheduled and included in the turnaround time performance criteria?
9. Is there a method to locate jobs that are delayed, and can requests about job status be answered easily?
10. Is there a standard methodology to prevent, detect and follow-up on processing errors?
11. Are the folowing items considered in the budget preparation:
    a) User demand and resource supply for computing services?
    b) Effect on "sales" of service, pricing, quality and responsiveness?
    c) The effect of commercial competition?
    d) How to generate new users?
12. Does the scheduling branch or section know where jobs are, and the status of all jobs on a continuing basis?

13. Are there differences in scheduling techniques used during prime time and non-prime time shifts? Is a shift differential applied to the job pricing scheme?
14. Does management receive periodic status reports on work scheduled, being processed, and completed?
15. Are there backup procedures for disk and tape files? How are files backed up?
16. Does the budget provide for:
    a) logical standards?
    b) comparison between budgeted and actual costs for work planned and accomplished?
    c) exclusion of those items over which management has no control?
    d) differentiation between budget goals and organizational goals?
    e) periodic examination of standards?
    f) participation in setting budgets by those who must live with them?
17. Is a chargeout or chargeback system required to make users aware of costs or to control costs and workload?
18. Are reimbursable charges correctly and accurately assessed to the appropriate customer?
19. Are rerun and downtime credits correctly incorporated into the billing system?
20. Is provision made for prompt expediting and feedback of information to management on variances between established budgets, schedules and actual accomplishments?
21. Does the pricing scheme measure and provide a basis for controlling user consumption of resources?
22. Is the budget process used as a mechanism to plan the provision of computing resources and determine their allocation?

23. If a charging system is used, are the following functions/characteristics included:
    a) Provide management information for resource control and decision-making?
    b) Provide a means of allocating resources among users?
    c) Encourage users to employ computing resources effectively and efficiently?
    d) Promote effective and efficient provision of services by the computer facility?
    e) Permit decentralization of control over resource allocation decisions?
    f) Tailored to the objectives it is to serve?
24. Does the management control system control user job arrival and internal job sequencing?
25. Are all operators familiar with Data Processing Center responsibilities cited in maintenance contracts?
26. Does the management control system monitor job prioritization in terms of hardware performance, software performance, or pricing?

## F. PERFORMANCE MEASUREMENT

1. Is there an individual or individuals within the Data Processing Center responsible for monitoring system performance?
2. Are there procedures to track and report resource utilization and system performance?
3. To whom and at what frequency do you report system performance measurements and resource capacity?
4. Are significant performance attributes measured, including capacities of resources for workloads, effectiveness in serving users, and efficiency in utilizing resources?

5. Is there a management system to review tasking ( or prioritizaton ) versus resources?
6. Is there a way to determine which applications use the most computer resources?
7. Can performance measures provide feedback to evaluate:
   a) validity of standards?
   b) success or failure to meet standards?
8. Are performance attributes based upon a balanced set of criteria so as not to sacrifice one factor for another?
9. Are the following performance measurement tools installed and utilized:
   a) operating system accounting packages?
   b) hardware monitors?
   c) software monitors?
   d) imbedded system monitors?
10. Are there reviews to assess which performance attributes are feasible to precisely and accurately measure?
11. Does the methodology for choosing performance measurements include the following:
   a) Identify the purpose for the measurement?
   b) Identify the relevant feasible attributes to be measured?
   c) Evaluate the measurements in terms of validity, reliability, and meaningfulness?
   d) Evaluate the cost and relevance of the measurement system?
12. Are measures of performance free from factors that are outside the control of the responsibility center?

G. STANDARDS

1. Are measurable, quantifiable standards established in terms of cost, quality, and schedules?
2. Are the standards based upon a balanced set of criteria so as not to sacrifice any one factor ( eg. quality, cost, or schedule ) for another?
3. Does the control system provide feedback to management to evalauate:
   a) The validity of standards?
   b) The success or failure at meeting standards?
4. Is there provision for establishing and disseminating new standards of performance when old ones are found to be inadequate or ineffective?
5. Are performance standards precise and communicated to the appropriate level of management?
6. Are standards for each organizational group reviewed to ensure that there is no conflict between groups?
7. Are standards reviewed for validity and is the performance level required by the standard consistent with the progress towards the goals and objectives?
8. Are standards constructed in such a way that they not only provide empirical data but also facilitate analysis in terms of patterns, trends, and indicators?

H. PERFORMANCE EVALUATION

1. Is downtime, rerun times, hardware/software problems recorded and reported for management action?
2. Does the manager have records, reports, and statistics needed to translate organizational objectives into terms of performance and corrective action?
3. Are provisions made for periodic spotchecks of work in process or completed work to ensure conformity to established standards?

4. Is Data Processing Center service to users within performance standards for scheduled jobs, unscheduled jobs, and on-line jobs?
5. Are there performance standards for each work area?
6. Are internal audits conducted on data processing management and operational functions to include the following areas:
   a) Adherence to organizaitons's policies, rules, and regulations?
   b) Efficient use of resources?
   c) Physical security of the data processing center?
   d) Documentation of standards and procedures?
   e) Long-range resource planning (facilities, equipment, etc.)?
7. Does the management control system provide a structure for continous audit trails?
8. Are persons responsible for meeting performance standards involved in:
   a) Setting of the standards?
   b) Collection, analysis, interpretation, and evaluation of the comparison data?
   c) Deciding what corrective action should be taken?
9. Do management reports have the following characteristics:
   a) Measure and evaluate all functions that contribute to attainment of the organizational goals?
   b) Tailored to specific functions and express performance in terms appropriate to that function?
   c) Contrast related measures of performance in such a manner that may indicate cause and effect relationships?
   d) Stated clearly and concisely?
   e) Measure performance against a predetermined standard?

f) Broad enough timeframe to allow historical background on which to base judgements of the performance?
g) Address resource utilization versus available capacity?
h) Prepared in an appropriate periodicity to allow timely corrective action?
i) Provide performance information to draw inferences on potential problems?
j) Facilitate trend analysis for organizational planning?

## I. PLANNING

1. Does the Data Processing Center participate in the development of user's functioonal requirements?
2. Is there a framework for integrating new application requests into the data processing center operations?
3. Are economic analysis techniques utilized in evaluating new applications and projects?
4. How are projected workloads determined?
5. Are personnel requirements projected in terms of future workload requirements?
6. Are budget estimates based on realistic, logical, supportable, and mathematically correct premises and standards?
7. Does long-range planning incorporate:
   a) organizational changes?
   b) technological changes?
   c) cost/benefit analysis?
   d) workload projections?
8. Are there contingency plans for the various types of processing disruptions which require operating with fewer resources or at another site?

9. Are personnel trained in contingency procedures? Are there periodic drills?
10. Does planning include:
    a) user participation?
    b) executive/steering committees?
    c) cost/benefit analysis?

## J. TRAINING

1. Does employee training include instructions on the responsibilities, requirements, and functions of their position?
2. Does employee training include instructions on the organization's objectives, standards, policies, procedures, and means of measuring performance?
3. Are there on-the-job training programs designed to increase technical proficiency and professional competence?
4. Are cross training programs available to broaden career paths and provide back-up skills in key positions?
5. Are employees encouraged to develop professional and technical competence through off-duty studies?
6. Is there a current and active annual training plan?

## K. PERSONNEL

1. By what means are data processing center personnel evaluated, paid, and promoted?
2. Are there any present or projected deficiencies or vacancies in any key positions?
3. Is there an upward employment path for employees that includes training and participation in the formulation of management policies and procedures?

4. Are personnel management goals reflected in the Command and Data Processing Center goals and objectives?
5. Have efforts been identified to attract and keep quality and experienced personnel?
6. Are personnel records maintained to ensure that all appropriate actions are documented?
7. Do position descriptions contain the current procedures and adequate job performance standards?
8. Do all position descriptions, procedures and policies reflect the latest performance objectives and requirements of the organization?
9. Are periodic position reviews performed on schedule?
10. Are periodic performance/evaluation reviews conducted on schedule?
11. Are supervisors performing prescribed supervisory responsibilities? Are there clear cut delegations of authority?
12. Have employees received written elements and performance standards for their positions?

## L. USER INTERFACE

1. Are the needs of users reviewed and are their opinions solicited as to the quality of services or products furnished?
2. Is there a procedure to inform the user community of system problems, expected downtime, and expected impact on user services?
3. Are regularly scheduled meetings held with the user community?
4. Is provision made for all complaints and recommendations from users to be recorded upon receipt, evaluated, acted upon, and answered?

5. Does the Data Processing Center participate in the development of user functional requirements?
6. Is there an active data center steering committee whose duties include:
   a) Coordination of data processing center and user activities?
   b) Resolution of scheduling difficulties?
   c) Data processing center's awareness of upcoming resource demands?
   d) User awareness of application processing problems and inefficiencies?
   e) Examination of alternative processing approaches?
7. Is there a user/data center handbook?
8. Is there a periodic review to verify the validity of user service agreements?
9. Are user service profile trends maintained?
10. If users have authority to purchase and operate commercially available software and hardware, what are the data processing center's maintenance responsibilities?
11. Is the user to required to use life-cycle management techniques in acquisition of software and hardware?
12. Is off-site hardware and software compatible with the data processing center's systems?
13. Are user and data processing center responsibilities defined and documented to prevent and reconcile areas of conflict?
14. Is the data processing center sensitive to the effect that the cost of service will have on user demand?

# VI. CONCLUSIONS

## A. SUMMARY

A management control system is the set of processes through which organizations ensure that actual activities conform to planned activities [Ref. 127]. The unique nature of the computing process, including hardware and software technology, user sophistication, and organizational structure, has introduced some specific considerations that need to be addressed when designing or evaluating the management control system at a Navy computing facility. The management control system must be able to respond to change and, in fact, evolve itself with ongoing changes in computer technology, software developments, and user demands for new applications.

The management control system of a computer facility involves significantly more than a daily measure of output per unit of input. Issues that influence and in some cases even dictate the type or structure of the management control system required by an organization are often long-termed and very broad in scope. Questions must be asked regarding: the stage of technological growth of the organization, the capability of the organization to measure either outputs or processes, the amount of task interdependence, the organizational structure and related mission, and a sense for the organization's planning and committment to meeting its objectives.

Non-financial controls are very important to the operational issues involved in a computer facility management control system, as are the traditional components of a financial architecture, a financial control process, and an

audit function. The management control system must include methods to provide for effective and efficient resource utilization and also a structure for auditing. The control system provides status of the organization's operations so that activities may be controlled in order to meet objectives and performance standards. Additionally, procedures and technology can be modified to permit setting of higher standards.

A management control system was described earlier as a critical network which integrates the organization's operations. It builds on the output of the planning process to develop projects, hardware and software improvements, facilities enhancements, and personnel requirements. The management control system is the common denominator in evaluating the organization's progress towards achieving its goals and objectives.

This study was conducted using traditional literature search techniques as well as visits to Navy Regional Data Automation Center, San Francisco, Naval Supply Center, Charleston, S.C., and Naval Supply Systems Command. The issues presented in this study represent the authors' efforts to provide some conceptual frameworks as well as practical evaluation criteria to aid a manager in assessing the management controls in a typical Navy computing facility. The concepts and evaluation guide presented herein will have to be tailored to the specific facility being evaluated.

## E. RECOMMENDATIONS

One of the first and most obvious discoveries made by the authors was the fact that there are vast differences between many of the Navy's computing facilities, while many similarities are also present. For this reason, the study

and the evaluation guide are intended to provide some discussion and insight to the many possible issues that impact on a manager in developing or evaluating the management control system at any particular Navy computing facility.

While many of the issues are discussed in great detail, some of the topics mentioned would be beyond the scope of this study to provide adequate guidance by itself. Economic analysis, for instance, should be thoroughly researched before attempting to apply the principles involved.

The best approach to using this paper and its included evaluation guide would be to gain a basic understanding of the organization with respect to the issues presented in the text of the study. Once that is accomplished, the evaluation guide can be used to conduct a step-by-step analysis through answering the questions provided.

## LIST OF REFERENCES


1. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

2. Ibid.

3. Ibid.

4. Ibid.

5. Webber, Ross A., Management: Basic Elements of Maraging Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1979.

6. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

7. Ibid.

8. Ibid.

9. Ouchi, William G., " A Conceptual Framework for the Design of Organizational Control Mechanisms," Management Science, v. 25, No. 9, September 1979.

10. Ibid.

11. Ibid.

12. Ibid.

13. Ibid.

14. Anthony, Robert N., Herzlinger, Regina E., Management Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

15. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

16. Ibid.

17. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

18. Ibid.

19. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

20. Martin, James, Design and Strategy for Distributed Data Processing, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

21. Rullo, Thomas A., Advances in Data Processing Management, Heyden and Son, Inc., Philadelphia, PA, 1980.

22. Ibid.

23. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

24. Ibid.

25. Anthony, Robert N., and Herzlinger, Regina E., Managment Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

26. Schechinger, Terry D., and Prack, Arthur E., III, An Analysis of the Computer System Chargeback Concept in the Naval Industrial Fund Environment, M.S. Thesis, Naval Postgraduate School, Monterey, CA, 1983.

27. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

28. Rullo, Thomas A., Advances in Data Processing Management, Heyden and Son, Inc., Philadelphia, PA, 1980.

29. Ibid.

30. Ibid.

31. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

32. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

33. Webber, Ross A., Management: Basic Elements of Managing Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1979.

34. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

35. Ibid.

36. Anthony, Robert N., and Herzlinger, Regina E., Management Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

37. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc. Englewood Cliffs, N.J., 1981.

38. Ibid.

39. Ibid.

40. Bernard, Dan, Emery, James C., and Nolan, Richard L., Charging for Computer Services: Principles and Guidelines, Petrocelli, New York, N.Y., 1977.

41. Ibid.

42. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

43. Ibid.

44. Ibid.

45. Ibid.

46. Ibid.

47. Ibid.

48. Ibid.

49. Ibid.

50. Zimmerman, Denise C. Economic Analysis Procedures for ADP, Naval Data Automation Command, Washington, D.C., 1980.

51. Jones, Carl R., U.S. Naval Postgraduate School, Monterey, CA., Personal Communication, 20 March 1984.

52. Zimmerman, Denise C. Economic Analysis Procedures for ADP, Naval Data Automation Command, Washington, D.C., 1980.

53. Frew, Barry A., U.S. Naval Postgraduate School, Monterey, Ca., Personal Communication, 22 February 1984.

54. Stoner, James A.F., Management, Prentice-Hall Inc., Englewood Cliffs, N.J., 1982

55. Ouchi, William G., "A Conceptual Framework for the Design of Organizational Control Mechanisms," Management Science, v. 25, No. 9, September 1979.

56. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L. Corporate Information Systems Management: Text and Cases, Richard D. Irwin, Inc., Homewood, Illinois, 1983.

57. Ibid.

58. Schechinger, Terry D., and Prack, Arthur E., III, An Analysis of the Computer System Chargeback Concept in the Naval Industrial Fund Environment, M.S. Thesis, Naval Postgraduate School, Monterey, Ca., 1983.

59. Bernard, Dan, Emery, James C., Nolan, Richard L., and Scott, Robert H., Charging for Computer Services: Principles and Guidelines, PetrocelLI, NewYork, N.Y., 1977.

60. Ibid.

61. Ouchi, William G., "A Conceptual Framework for the Design of Organizational Control Mechanisms", Management Science, v. 25, No. 9, September 1979.

62. Ibid.

63. McKell, L.J., Hansen, J.V., and Heitger, L.E., "Charging for Computer Services", Computing Surveys, June 1979.

64. Bernard, Dan, Emery, James C., Nolan, Richard L., and Scott, Robert H., Charging for Computer Services: Principles and Guidelines, PetrocelLI, New York, N.Y., 1977.

65. Ibid.

66. Naval Supply Systems Command, Capacity Analysis Reporting System, April 1983.

67. Ibid.

68. Euske, Kenneth J., Management Control: Planning, Control, Measurement, and Evaluation, Addison-Wesley Publishing Company, Reading, Ma., 1984.

69. Ouchi, William G., "A Conceptual Framework for the Design of Organizational Control Mechanisms", Management Science, v. 25, No. 9, September 1979.

70. Euske, Kenneth J., Management Control: Planning, Control, Measurement, and Evaluation, Addison-Wesley Publishing Company, Reading, PA., 1984.

71. Ibid.

72. Ibid.

73. Ibid

74. Ibid.

75. Anthony, Robert N., and Herzlinger, Regina E., Management Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

76. Ibid.

77. Axelrod, C. Warren, Computer Effectiveness: Bridging the Management Technology Gap, Information Resources Press, Washingtcn, D.C., 1979.

78. Ibid.

79. Ibid.

80. Ibid.

81. Ibid.

82. Ibid.

83. Ibid.

84. Ibid.

85. Ibid.

86. Ibid

87. Ibid.

88. Ibid

89. Ibid.

90. Ibid.

91. Ibid.

92. Ibid.

93. Ibid.

94. Schaeffer, Howard, Data Center Operations, Prentice-Hall Inc., Englewood Cliffs, N.J., 1981.

95. Ibid.

96. Ibid.

97. Ibid.

98. Gore, Marvin and Stubbe, John, Elements of Systems Analysis, William C. Brown Co. Publishers, Dubuque, Iowa, 1983.

99. Thompson, James D., Organizations in Action, McGraw-Hill Book Company, New York, N.Y., 1967.

100. Webber, Ross A., Management: Basic Elements of Managing Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1979.

101. Ibid

102. Ibid.

103. Anthony, Robert N., and Herzlinger, Regina E., Management Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

104. Ibid.

105. Haga, William J., U.S. Naval Postgraduate School, Monterey, CA., Personal Communication, September 1983.

106. Anthony, Robert N., and Herzlinger, Regina E., Management Controls in Nonprofit Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1980.

107. Ibid.

108. Martin, James, Design and Strategy for Distributed Data Processing, Prentice-Hall Inc., Englewood Cliffs, N.J., 1981.

109. Ibid.

110. Ibid.

111. Boore, William F., and Murphy, Jerry R., The Computer Sampler: Management Perspectives on the Computer, McGraw-Hill Book Company, New York, N.Y., 1968.

112. Ouchi, William G., "A Conceptual Framework for the Design of Organizational Control Mechanisms", Management Science, v. 25, No. 9, September 1979.

113. Ibid.

114. Schaeffer, Howard Data Center Operations, Prentice-Hall Inc., Englewood Cliffs, N.J., 1981.

115. Ibid.

116. Ibid.

117. Ibid.

118. Ibid.

119. Webber, Ross A., Management: Basic Elements of Managing Organizations, Richard D. Irwin, Inc., Homewood, Illinois, 1979.

120. Ouchi, William G., "A Conceptual Framework for the Design of Organizational Control Mechanisms", Management Science, v.25, No. 9, September 1979.

121. Schaeffer, Howard, Data Center Operations, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1981.

122. Naval Supply Systems Command Capacity Analysis Reporting System, April 1983.

123. Ibid.

124. Webber, Ross A., Management: Basic Elements of Managing Organizations, Richard D. Irwin Inc., Homewood, Illinois, 1979.

125. Ibid.

126. Ibid.

127. Cash, James I., Jr., McFarland, F. Warren, and McKenney, James L., Corporate Information Systems Management:Text and Cases, Richard D. Irwin Inc., Homewood, Illinois, 1983.

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